RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

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RECORDS
OF
THE GEOLOGICAL SURVEY OF INDIA

Part I.] 1923 [July.

GENERAL REPORT FOR 1922. BY E. H. PASCOE, M.A., SC.D. (Cantab.), D.Sc. (Lond.), F.G.S., F.A.S.B., *Director, Geological Survey of India.*

DISPOSITION LIST.

1. During the period under report the officers of the Department were employed as follows:—

Superintendents.

Mr. E. VREDENBURG .	In charge of the Bihar and Orissa and Central Provinces Party. Granted combined leave for one year and four months with effect from the 18th August 1922.
Dr. L. L. FERMOR .	Continued to officiate as Director up to the 17th September 1922. Granted combined leave for thirteen months and fourteen days with effect from the 19th September 1922.
Dr. G. E. PILGRIM .	Returned from field work in charge of the North-Western Party on the 16th April 1922. Granted combined leave for one year and six months with effect from the 22nd May 1922.

Mr. G. H. TIPPER . Placed in charge of office up to the 10th April 1922, and continued to act as Palæontologist till the 26th April 1922. Left for Chitral on the 28th April 1922 and returned from the field on the 11th November 1922. Again placed in charge of office on the 21st December 1922.

Dr. G. de P. COTTER . In charge of the Burma Party.

Dr. J. COGGIN BROWN . Returned from privilege leave on the 13th March 1922. Placed in charge of office from the 11th April to the 20th December 1922. Appointed Palæontologist on the 27th April 1922.

Assistant Superintendents.

Mr. H. WALKER . . Returned to headquarters from the field on the 4th May 1922. Granted leave on average pay for one month from the 9th November 1922. Attached to the Bihar and Orissa and Central Provinces Party; left for the field (Central Provinces) on the 22nd December 1922.

Mr. K. A. K. HALLOWES Returned to headquarters from Hyderabad (Deccan) on the 16th April 1922. Proceeded again to Hyderabad for field work on the 4th November 1922.

Mr. H. C. JONES Continued to officiate as Superintendent with effect from the 26th January 1920. Returned to headquarters from Bihar and Orissa on the 20th March 1922. Left for the Bombay Presidency and Baroda on the 26th March 1922 to investigate the kaolin deposits of the Ratnagiri District, mineral resources of the Kolhapur State and gas seepages of Baroda;

	returned to headquarters on the 29th June 1922. Placed in charge of the Bihar and Orissa and Central Provinces Party ; left for the field on the 14th November 1922.
Dr. A. M. HERON .	Returned to headquarters from Burma on the 5th March 1922. Appointed to officiate as Superintendent from the 22nd May 1922. Placed in charge of the Bombay and Rajputana Party ; left for field work in Rajputana on the 1st November 1922.
Mr. C. S. FOX . .	On deputation in the office of the High Commissioner for India.
Rao Bahadur S. SETHU RAMA RAU.	Returned to headquarters from field work in the Central Provinces on the 6th May 1922. Attached to the Burma Party ; left for the field on the 10th November 1922.
Rao Bahadur M. VINAYAK RAO.	Returned to headquarters from field work in Burma on the 28th March 1922. Attached to the Bombay and Rajputana Party to investigate the salt deposits of the Rann of Kachh ; left for field work on the 21st October 1922.
Mr. H. CROOKSHANK .	Continued to act as Curator, Geological Museum and Laboratory.
Captain C. T. TEYCHENNÉ.	Granted an extension of leave for fifteen months and twenty-two days without allowances with effect from the 5th May 1922.

Mr. E. L. G. CLEGG . Returned to headquarters from the field on the 28th May 1922. Left headquarters on the 29th October 1922 to examine a dam site on the Barakar river and returned on the 1st November 1922. Attached to the Burma Party; left for the field on the 5th November 1922.

Mr. D. N. WADIA Returned to headquarters from the field on the 30th June 1922. Attached to the North-Western Party; left for the field on the 3rd November 1922 and investigated the coal deposits of Ramnagar *en route*.

Mr. G. V. HOBSON Returned to headquarters from the field on the 4th May 1922. Left headquarters for Nellore on the 26th October 1922 to inspect the mica mining area there. Attached to the Bihar and Orissa and Central Provinces Party to examine the mica deposits of the Kodarma forest.

Captain F. W. WALKER. Returned to headquarters from the field on the 20th April 1922. Left Calcutta on the 25th April 1922 for Assam, to examine occurrence of corundum and sillimanite and to inspect certain reservoir sites near Cherrapunji; returned on the 9th June 1922. Attached to the Burma Party; left for Rangoon on the 5th November 1922.

Mr. J. A. DUNN . Attached to the Bihar and Orissa and Central Provinces Party; left for the field (Bihar and Orissa) on the 11th January 1922. Returned to headquarters on the 18th May 1922. Granted leave on medical certificate on half

average pay for six months from the 16th July 1922. Permitted to return and resume duty on the 23rd November 1922. Attached to the Bihar and Orissa and Central Provinces Party; left for the field (Bihar and Orissa) on the 29th November 1922.

Mr. A. L. COULSON .	Appointed Assistant Superintendent, Geological Survey of India, on the 25th November 1922. Attached to the Central Indian Coalfields Railway Survey; left headquarters for field work on the 19th December 1922.

Chemist.

Dr. W. A. K. CHRISTIE .	At headquarters up to the 6th April 1922. Granted combined leave for nine months from the 7th April 1922.

Artist.

Mr. K. F. WATKINSON	At headquarters.

Sub-Assistants.

Babu BANKIM BIHARI GUPTA.	Returned to headquarters from field work in Burma on the 9th May 1922. Attached to the Burma Party; left for the field on the 10th November 1922.
Babu DURGASHANKAR BHATTACHARJI.	Returned from field work in the Central Provinces on the 3rd April 1922. Granted leave on average pay for one month and fourteen days from the 4th April 1922. Attached to the Bihar and Orissa and Central Provinces Party; left for the field (Central Provinces) on the 20th October 1922.

Babu BARADA CHARAN GUPTA.	At headquarters as Assistant Curator up to the 6th June 1922. Granted leave on average pay for two months and 15 days from the 3rd January 1922. Appointed Sub-Assistant on the 7th June 1922. Attached to the Bombay and Rajputana Party; left for the field (Rajputana) on the 1st November 1922.
Babu HARENDRA MOHAN LAHIRI.	Appointed Sub Assistant on the 7th June 1922. At headquarters.
M. R. RY. L. A. NARAYANA IYER.	Appointed Sub-Assistant on the 12th July 1922. Attached to the Bombay and Rajputana Party; left for the field (Rajputana) on the 1st November 1922.

Assistant Curator.

Babu PURNA CHANDRA ROY.	Appointed on the 3rd August 1922. At headquarters.

2. The cadre of the Department continued to be 6 Superintendents, 22 Assistant Superintendents and one Chemist. Of the 8 vacancies in the grade of Assistant Superintendents existing in 1921, one was filled during the year, leaving at the end of the year seven vacancies.

ADMINISTRATIVE CHANGES.

Promotions and appointments.

3. Dr. L. L. Fermor who was appointed to officiate as Director, reverted to his substantive appointment of Superintendent on the 18th September 1922, on the return from leave of Dr. E. H. Pascoe, Director.

Mr. H. C. Jones continued to officiate as Superintendent up to the 27th September 1922, *vice* Dr. L. L. Fermor, officiating as Director, and from the 18th September 1922 *vice* Mr. E. Vredenburg on leave.

Dr. A. M. Heron was appointed to officiate as Superintendent from the 22nd May 1922, *vice* Dr. G. E. Pilgrim on leave.

Mr. G. H. Tipper continued to act as Palæontologist till the 26th April 1922, and thereafter Dr. J. Coggin Brown from the 27th April 1922.

Messrs. H. Crookshank and E. L. G. Clegg have been confirmed in their appointments as Assistant Superintendents.

Mr. A. L. Coulson, M.Sc. (Melbourne), was appointed Assistant Superintendent on the 25th November 1922.

The following Sub-Assistants were appointed during the year :—

Babu Barada Charan Gupta, on the 7th June 1922.

Babu Harendra Mohan Lahiri, M.Sc. (Calcutta), on the 7th June 1922.

M. R. Ry. L. A. Narayana Iyer, M.A. (Madras), on the 12th July 1922.

M. R. Ry. N. K. Narasimha Aiyengar, B.A. (Madras), was appointed Field Collector from 2nd August 1922.

Leave.

4. Mr. E. Vredenburg was granted combined leave for one year and four months with effect from the 18th August 1922.

Dr. L. L. Fermor was granted combined leave for thirteen months and fourteen days with effect from the 19th September 1922.

Dr. G. E. Pilgrim was granted combined leave for one year and six months with effect from the 22nd May 1922.

Mr. H. Walker was granted leave on average pay for one month with effect from the 9th November 1922.

Captain C. T. Teychenné was granted an extension of leave for fifteen months and twenty-two days without allowances with effect from the 5th May 1922.

Mr. J. A. Dunn was granted leave on medical certificate on half average pay for six months with effect from the 16th July 1922.

Dr. W. A. K. Christie was granted combined leave for nine months with effect from the 7th April 1922.

Babu Durgashankar Bhattacharji was granted leave on average pay for one month and fourteen days with effect from the 4th April 1922.

Babu Barada Charan Gupta was granted leave on average pay for two months and fifteen days with effect from the 3rd January 1922.

OBITUARY.

5. The death of Captain R. W. Palmer, who was an Assistant Superintendent in this Department from 1913 to 1921 has been referred to in the Records, Geological Survey of India, Vol. LIV, page 241.

PROFESSORSHIP AND LECTURESHIP.

6. Mr. Vredenburg was Professor of Geology at the Calcutta University up to the 17th August 1922. Mr. H. Crookshank continued as Lecturer on Geology at the Presidency College throughout the year.

POPULAR LECTURES.

Two popular geological lectures, one on "The Tibetan Frontier," and the other on "Tenasserim and the Siamese Frontier" were delivered in the Indian Museum during the Monsoon by Dr. A. M. Heron.

LIBRARY.

The additions to the Library amounted to 4,682 volumes, of which 1,306 were acquired by purchase and 3,376 by presentation and exchange.

PUBLICATIONS.

The following publications were issued during the year under report :—

Memoirs, Vol. XLI, Pt. 1 (Reprinted).
,, ,, XLVIII ,, 1.
Records, ,, LIII ,, 2 and 3.
,, ,, LIV ,, 1 and 2.
Palæontologia Indica, New Series, Vol. VI, Memoir No. 2.

MUSEUM AND LABORATORY.

Staff.

Mr. H. Crookshank was Curator of the Geological Museum and Laboratory during the year. From the beginning of the year to the 3rd August Babu Barada Charan Gupta was Assistant Curator. On the latter date he handed over his post to Babu Purna Chandra Roy.

Chemist.

Dr. W. A. K. Christie, Chemist, was on combined leave from the 6th April till the end of the year. He studied at the *Muséum national d' Histoire naturelle* in Paris, the University of Geneva, and the *Technische Hochschule* in Graz.

Determinative work and analyses.

The number of specimens referred to the Curator for examination and report was 497. Assays and analyses were made of 102 specimens. The corresponding figures for the preceding year were 544 and 89.

Meteorites.

During the year the following acquisition to the meteorite collection was made :—

A meteoric iron, which fell on the 20th May 1921 at the village of Beshkalai, in the Banera chiefship, Mewar. The piece weighs 749·51 grammes, and is part of the fall north-west of Shahpura noted in last year's General Report.

During a thunderstorm at Quetta on the afternoon of the 25th January, 1923, a large ball of fire is reported to have fallen and struck a stack of baled *bhoosa* in the Military Grass Farm Stackyard. The stack, composed of 12,800 bales, was for the most part consumed by fire, and amongst the ashes were found some three tons of a hard dark stone. Portions of this stone were forwarded to the laboratory of the Geological Survey and found to consist of slag, parts of which shewed a ropy structure and slightly scoriaceous texture. As the report stated that no one had actually seen the fire ball strike the stack, it was at first thought that the latter was ignited by a simple flash of lightning. Later information however makes it possible that a meteorite did actually fall into the *bhoosa* stack. Not only was the "ball of fire" witnessed by several people, but the men who were set to work on top of the stack extinguishing the fire immediately after its outbreak, reported a hole in the stack 18 inches wide, and their observation was confirmed by Conductor Trewhella who noticed that the hole led towards the centre of the stack.

There seems little doubt that the *bhoosa* was struck and ignited either by a meteorite which burned its way to the base of the stack, or by a simple flash of lightning. The intense heat fused the iron bands binding the bales of *bhoosa* and this iron combined with the silica in the *bhoosa* itself and mixed with any mud roofing which may have been present. Mr. A. J. Gibson of the Punjab Forest Service has reminded me that the tissues of the Gramineae contain an unusually large percentage of silica, and 12,000 bales would probably supply

sufficient to form most of the three tons of slag, consisting of free iron silicate of iron, and impurities. The meteorite, if there were one, was itself probably of iron, and would have mixed with and become part of the fused slag. Unmelted fragments of the iron bands of the *bhoosa* bales were found in the cooler portions of the melt. In such circumstances it is of course impossible to identify any remains of a meteorite in the slag.

Donations to Museums, etc.

During the year presentations of geological specimens were made to the following institutions :—

(1) The Imperial Mineral Resources Bureau, London.
(2) The Royal Ontario Museum of Mineralogy.
(3) The Lady Hardinge Medical College for Women, Delhi.
(4) The Mohilashram, Poona City.
(5) The Jnan Bhandar Museum, Agra.
(6) The Indian Trade Commissioner in London.
(7) The Department of Glass Technology, Sheffield.
(8) The Patna Museum.
(9) Presidency College, Calcutta.
(10) The Geophysical Laboratory, Carnegie Institution of Washington.
(11) The *Muséum national d' Histoire naturelle*. Paris.
(12) The State University of Iowa.

Additions to the collections.

The following foreign specimens were added to the collections during the year :—

(1) Bentonite, Canada. From the Imperial Mineral Resources Bureau.
(2) Otaylite, Canada. From the Imperial Mineral Resources Bureau.
(3) Green earth, Bohemia. Presented by Messrs. Pegg and Ellam Jones, Ltd.
(4) Six different varieties of sand from the United States of America. Presented by Mr. C. K. Wentworth, Iowa University.

Among the Indian specimens added to the collections during the year are the following :—

(1) A boulder of quartz with slickensided carbonaceous coating from the Coal Measures, Rewa State Collieries, Umaria, Central India. Presented by Mr. J. E. Tyres.

(2) Zircon, ilmenite, and monazite sands, Travancore. Presented by the Travancore Mineral Company, Ltd.
(3) A collection of zeolites from Bombay. Purchased from Mr. Ribeiro.
(4) Zircon crystals, Vizagapatam district, Madras. Presented by Mr. V. S. Sambasiva Iyer.
(5) Massive apatite, Vizagapatam district, Madras. Presented by Mr. V. S. Sambasiva Iyer.

All-India Industrial Exhibition.

An exhibit of interesting Indian minerals and the work of the drawing office was shown at the All-India Industrial Exhibition.

PALÆONTOLOGY.

During the year Dr. Cowper Reed's memoir entitled "Devonian Fossils from Chitral and the Pamirs" was published in the *Palæontologia Indica*, as Vol. VI, Memoir No. 2 of the New Series. The specimens themselves were collected by Sir Henry Hayden in 1914 and their description has added considerably to our very scanty knowledge of the stratigraphy and fossils of these isolated regions. The same author's account of the Upper Carboniferous fauna of Chitral and the Pamirs is in proof and will be published as soon as possible. Dr. Cowper Reed has also been engaged in studying the Carboniferous, Permian and Triassic fossils collected in Yunnan some years ago by Dr. J. Coggin Brown.

Mr. LaTouche's Palæontological Index is in an advanced stage of printing and is to be issued as Part 4, of the Bibliography of Indian Geology. The plates illustrating Dr. Erich Spengler's memoir entitled "Contributions to the Palæontology of Assam" having been received from Europe, instructions have been given to issue the memoir in the *Palæontologia Indica* at once. Dr. G. de P. Cotter's "Lamellibranchiata of the Eocene of Burma," is also to be issued shortly.

Mr. Vredenburg's comparative diagnoses of certain families of gastropoda, mainly from the Tertiary formations of Burma, were continued by the submission of papers dealing (*a*) with the *Olividæ*, *Harpidæ*, *Marginellidæ*, *Volutidæ* and *Mitridæ* and (*b*), with the *Fusidæ*, *Turbinellidæ*, *Chrysodomidæ*, *Strepuridæ*, *Buccinidæ*, *Vassidæ*, and *Columbellidæ*. The first of these will appear shortly in *Records* LIV, Part 3. Two other papers by the same writer were

published in the Records during the year, *viz.*, "Analysis of the Singu Fauna founded on Rao Bahadur S. Sethu Rama Rau's collections," and "A Zone-Fossil from Burma: *Ampullina (Megatylotus) Birmanica.*" Mr. Vredenburg's "Mollusca from the Post-Eocene Tertiary formations of North-West India," his "Review of the genus *Gisortia*" and a smaller paper entitled "Oligocene Echinoidea collected by Rao Bahadur Sethu Rama Rau in Burma" are in the Press.

Other works either in the course of printing or accepted for publication include Mr. Forster Cooper's "*Anthracotheridae* of the Dera Bugti deposits in Baluchistan"; Mr. T. H. Withers' "Revision of some Fossil Balanomorph Barnacles from India and the East Indian Archipelago"; the late Captain R. W. Palmer's "An incomplete skull of Dinotherium, with notes on Indian forms"; Prof. Sahni's paper "On the structure of the cuticle in *Glossopteris angustifolia* Brongn."; Dr. Matley's "Note on an armoured Dinosaur from the Lameta Beds of Jubbulpore"; Mr. Vredenburg's paper "On the Phylogeny of some Turbinellidæ"; and another paper by the same author entitled "On some Fossil Forms of Placuna." Routine determinative work from extra-departmental sources, carried on by the officers who have held the post of Palæontologist during the year, included the examination of fossil collections—some of them of considerable size—from the Triassic rocks of the Aden Hinterland, the Triassic of Bikaner, the Nummulitic of the North-West Frontier Province and of Sind, the Tertiary of Burma, Assam and Persia, and the Carboniferous and Cretaceous of Tibet.

In Europe, Dr. G. E. Pilgrim is spending his study leave, continuing his researches on Indian Siwalik Vertebrates, while Mr. E. W. Vredenburg, until his untimely death, was investigating Indian Tertiary Foraminifera.

The fossil collections of the department are becoming of increasing assistance to geologists in private employment, and during 1922 permission was granted to several enquirers to make comparative studies of their own material in the Geological Survey Office. This development emphasises the growing appreciation of the bearing of the purely scientific side of Geology in the form of palæontology on economic questions especially on those connected with the petroleum industry concerned with the correlation of oil horizons.

In September I was informed by the Collector of Bandra that he had found on the foreshore at Bandra the remains of fossil animals

in what he considered to be Inter-Trappean beds. Rao Bahadur M. Vinayak Rao was requested to investigate the find. On being shown the locality by the Assistant Collector, he found that the remains had no structure and occurred in some thin bands of highly indurated shales overlain by ash-beds; they formed irregular dark bands in the lighter coloured ash-beds. The shales are either small local patches of Inter-Trappeans, or are fragments of these rocks caught up by the lava. Some of the dark shale bands have rounded and elongated shapes resembling crocodiles and other similar forms, but M. Vinayak Rao could find no relics of actual bones, nor could he identify any impressions of skin or other parts of the body. He concluded that the impressions were not of animal origin.

ECONOMIC ENQUIRIES.

Aquamarine.

Chitral.

While in Chitral, Mr. G. H. Tipper discovered that a large area in the western part of the State, forming the high ground between Afghanistan (Kafiristan and Wakhan) and Chitral, is composed of garnetiferous and chiastolite-bearing schists with large masses of granitic intrusions. These intrusions are variable in size and mode of occurrence, and are generally fine-grained. The intrusions sometimes occur parallel to the planes of schistosity, but at other times cut through the schists at all angles converting the mass into a breccia on a large scale. In one of the coarser intrusions at Sirwigh-o-gaz (12,000 feet), a summer grazing ground on the road from the Lutkuh to the Arkari, beryls occur. A few beryls of poor quality, white and badly flawed were seen *in situ*. In the sandy débris below the rock, good hexagonal crystals can be found in considerable quantities. These are of very pleasing colour, the majority being rather badly cracked and containing lines of inclusions parallel to the basal cleavage. Some of the specimens are, however, almost of gem quality and the locality is worth further prospecting.

Arsenic.

Chitral.

During his work in Chitral, Mr. G. H. Tipper visited a new discovery of arsenic sulphide near the village of Partsan. At this locality the ore consists entirely of realgar, the red sulphide. The mineral occurs as scattered particles and in nests in the calcareous shales over a width varying from a

few inches to several feet. The deposit apparently runs in the direction of strike, and although not so rich as some of the deposits seen last year, is promising. The geological structure in the neighbourhood is complicated by faulting and it remains to be seen by further development whether the deposit has any persistence. The rocks in which the arsenic sulphide occurs are of Cretaceous age and have been let down by two large strike faults. Locally also there is minor faulting and thrusting.

Asbestos.

Chitral.

During the survey of the Shishi Kuh, the valley forming the geological continuation of the southern portion of the Chitral valley below Drosh, Mr. Tipper found large masses of basic igneous rocks in many places converted into serpentine. A white, asbestiform mineral has been formed in veins and cracks in the serpentine. In spite of a very thorough search no deposit of any size was discovered. Such as does occur is harsh, brittle and of poor quality.

Bauxite.

Kolhapur State.

During the latter part of field-season 1921-22, Mr. H. C. Jones carried out a mineral survey of the Kolhapur State, Bombay, the main purpose of which was to obtain information regarding the occurrence of bauxite in the State. A report of this work is being published in the Records. Mr. Jones has located several deposits of bauxite of good quality, which are worth further attention from prospectors; these deposits occur near the edge of the Western Ghats, where water-power schemes are feasible.

Coal.

Ramnagar : Bihar and Orissa.

At the request of the Government of Bihar and Orissa, a brief visit was made to some reported coal-seams in the Ramnagar Raj of the Champaran district, Bihar and Orissa. Mr. D. N. Wadia was deputed for this purpose, and reports that he could find nothing more than a few stringers and pockets of lignite of Siwalik age. One of these pockets was pointed out to him as the Ramnagar coal bed. The analysis of a specimen previously sent to the Geological Survey Laboratory showed a high percentage of carbon, but this evidently cannot be regarded as a representative sample of these deposits. No true

seams of coal were observed by Mr. Wadia. nor could he obtain any information of any true seams having been observed.

Mergui ; Burma.

Tertiary coal of some thickness was observed by M. Vinayak Rao in Leikpokchaung, south of the Mabaleik mines, and may continue beneath the alluvium of the Little Tenasserim and its tributaries.

Loi-an coal-field, Southern Shan States : Burma.

The Loi-an coalfield, near Kalaw in the Southern Shan States of Burma, was re-examined by Dr. Cotter and Captain F. W. Walker in January and February, 1922. The coal, which is of Gondwana. and not of Tertiary age as was formerly supposed, has been very much crushed by earth movements. This has made the coal friable, and may necessitate some sort of briquetting ; it also adds to the difficulties of mining, as the mineral does not stand any considerable weight or pressure. The seams are irregular and dip mostly at high angles, while faulting and contortion are prevalent. Some of the seams, nevertheless, appear to be of good quality, and further prospecting is advisable.

Copper and Manganese.

Chitral.

In 1921 Mr. G. H. Tipper had noted the presence of traces of copper as incrustations on cracks in the granite of Mirkanni at the foot of the Laorai pass in Chitral. During the present season it was found that this granite extends on both sides of the Chitral river into Afghan territory on the south-west. Associated with this granite are basic rocks as dykes and segregation patches. The latter rocks are often serpentinised, and when they occur as segregation patches. the granite in the neighbourhood contains copper pyrites, often decomposed to carbonates.

In the basic patches, notably near the village of Damel. occur masses of a soft black mineral which on exmination proves to be manganese ore. No chromite was found.

The occurrences are of interest but of no economic value.

Engineering Questions and Allied Enquiries.

Dam sites ; Cherrapunji.

During last year Captain F. W. Walker made an examination of two dam sites near Cherrapunji. provisionally selected by the Assam party of the Hydro-Electric Survey of India. One of the sites is situated about 2 miles south-west of the village of Laitryn-

gew at mile "27" on the Shillong-Cherrapunji road, where the proposal is to construct a dam across the Um Pynjngithuli, and to impound the waters in the upper reaches of the stream where the valley widens out. The other site known as the Raitang site is on the Um Long, 1½ miles west of mile "30" on the Shillong-Cherrapunji road. Both sites were selected at points where valleys narrow down and where the length of the dams would be quite short. The impounding areas, on the other hand, are broad, flat valleys enclosed on both sides by hill ranges extending well above the proposed high water level. The rocks of the neighbourhood, according to a survey by the late Captain R. W. Palmer, include granites and quartzites of the Shillong series, Cretaceous sandstone and Nummulitic limestone. The two selected dam sites are situated on the Cretaceous sandstone, while the Nummulitic limestone is met with in the higher levels of the impounding areas. Both sandstone and limestone lie practically horizontally and no evidence of unconformity was observed between the two. At the Laitryngew site, where the proposed dam would run from east to west, the Cretaceous sandstone consists of fine grains of quartz set in a ferruginous matrix. Although the rock is somewhat porous, Captain Walker considered it was firm enough to hold the dam, provided the foundations were sunk deep enough to escape a carbonaceous layer which was found in some experimental pits at a depth of about 7 feet. This carbonaceous layer is more friable than the rest of the sandstone, but it was concluded that the former rock would be found recurring below the carbonaceous layer. The limestone, which would enclose the water only at the higher levels, would be under no great pressure and should be quite suitable for holding up the water. The junction between the limestone and the sandstone appears to be sufficiently tight to prevent leakage along this plane. Although the sandstone is porous and a considerable amount of leakage may be expected, the Laitryngew site is looked upon as suitable for the proposed scheme.

At the Raitang site the length of the dam would be about 1,000 feet and its height 80 feet. The same Cretaceous sandstone as was found at Laitryngew, is found here, but in a more friable form and contaminated with subordinate layers of earthy carbonaceous matter. A specimen exposed to the atmosphere in Calcu a for some months completely disintegrated, the carbonaceous material crumbling into a fine earthy powder while the sandstone layers remained intact,

A rock of this type is unsuitable either for a dam foundation, or for retaining water; percolation would take place through the carbonaceous layers, which, moreover, would be incapable of sustaining pressures such as those to which the foundation work of a dam is subjected.

Palkai Dam Scheme.

The Bengal Public Works Department, Irrigation Branch, in connection with their proposed scheme for constructing dams at various points on the Damodar and Barakar rivers in order to regulate the flow of water and prevent flooding in the Burdwan area during heavy rains, consulted this Department on the advisability of erecting one of these dams at Palkai, half a mile below the confluence of the Usiri tributary with the Barakar river. The proposed dam would, during times of flood, cause the inundation of the higher reaches of the river to the 760-ft. contour level, the inundated area including about 4½ square miles of Talchir rocks. As the Talchir rocks are sometimes found to contain good coal-seams, it was thought advisable to confirm previous reports that no coal had been noticed in the area. Mr. E. L. G. Clegg was deputed for this work, and was able to confirm the previous observers as to the absence of any surface indications of coal. The rocks belong to the Conglomerate stage of the Talchir Series, and would form a suitable foundation for the erection of a dam.

Sand-stowing on the Damodar.

It scarcely needed a visit from Mr. Trehearne Rees to make us aware of the great waste which up to the present has occurred in the extraction of coal from the coal mines of India. With a view to decreasing this waste various schemes have been propounded, the most satisfactory of which is that of sand-stowing. Amongst other uncertain factors in the feasibility of such a scheme was that of the supply of sand, and Mr. G. V. Hobson was sent to make an examination of portions of the Damodar river in order to ascertain whether an adequate supply of sand could be reasonably counted upon. Mr. Hobson confined his attention to two representative sections—the first lying between Burkunda and Ramgarh, and the other extending past Bermo. Altogether about 41 miles of the river were surveyed. With regard to the first section, the conclusion come to was that the river was narrower and the sand deposits not so deep as in the Bermo area, but that the probabilities are that the supplies would be sufficient for sand-packing in

the Karanpura field, and would be replaced soon after removal. With regard to the Bermo section, a very good supply of sand extending over a width averaging about a thousand feet may be looked for. At one spot north-west of Chalkari a rod penetrated 17 feet of sand without reaching the rock bottom. A quarter of a mile above the outlet of the Bokaro, where a railway bridge is in course of erection across the Kunar Nala, there is a depth of 30 feet of sand. At a bridge across the Bokaro Nala 12 miles up stream, the sand was reported to have a depth of 20 feet over a width of 200 feet. Mr. Hobson notes that the Damodar river and its tributaries tap a considerable area of country, much of which is composed of sedimentary rock yielding a large proportion of sand. Every streamlet and tributary appears to bring down large quantities of sand, which would in all probability be quite sufficient to replace any extracted from the river for sand-stowing purposes.

Yunzalin dam ; Burma.

In connection with the hydro-electric scheme for impounding the waters of the upper reaches of the Yunzalin river and its tributaries in Burma, Mr. E. L. G. Clegg was requested to examine the sites proposed and to report on their suitability from the geological point of view. With the exception of the fissured crystalline limestones all the rocks of the area are impervious and suitable for the bed of a reservoir. The crystalline limestones occur as outliers on these impervious rocks and since all the exposures are totally included in the Yunzalin catchment area, they will have no detrimental effect on any dam site from a water-holding standpoint. The sites examined comprise the main Yunzalin site, about 500 yards east of the Yunzalin-Thelaw Klo junctions, the Pyagawpu main dam situated one mile south-east of Pyagawpu, and the two stop-gap dams—one at Bilin two miles S. S. E. of Pyagawpu and the other in the Kailaw Klo basin half a mile south of Pyagawpu. All these dam-sites are situated on slate or quartzite, *i.e.*, impervious rocks which strike across the water channels. The valley slopes are stable. Mr. Clegg considers that the area is suitable for an impoundment area and the dam-site satisfactory for the construction of dams. Granite, quartzite, limestone, sand and clay are locally obtainable, and would be useful for constructional work.

Sutlej Dam ; Punjab.

Dr. Pilgrim visited the State of Nalagarh in order to advise the Engineer in charge of the proposed quarries which it was hoped would provide the stone

required for the dam projects on the Sutlej. He had no hesitation in supporting their choice of a site and in expressing the opinion that sufficient stone for the purpose was actually in sight unless some rapid change in the strata should take place. Such a change was considered unlikely at the site chosen, but is always a possibility in the freshwater sandstones in which it was proposed to quarry.

Fire-clay and Brick-clay.

Jubbulpore.

During the year under review, Mr. H. Walker paid a visit to the Gun Carriage Factory Estate at Jubbulpore with the object of examining the ground for minerals of economic value. The southern portion of this area had been surveyed by Messrs. Medlicott and Mallet and recently by Dr. C. A. Matley. This portion of the Estate is occupied by Deccan Trap, Lameta beds and Jabalpur Clays and Sandstone. The limestone bands of the Lameta group are worked on a small scale for the production of lime, while the "white clays" of the Jabalpur group are fire-clays of economic value, as the Pottery Works at Jubbulpore prove. Mr. Walker found the rocks of the northern portion of the Estate to consist of gneissose granites. Here there are considerable areas of common surface clays which are being utilised for brick-making: beyond this nothing of economic value was observed.

Garnets.

Chitral.

In Chitral Mr. Tipper found that garnets are widely developed and occur in the banded gneisses, in garnetiferous schists and in the granitic rocks cutting the latter. Many of the garnets are of pleasing colour but are usually too flawed to be of value as gem-stones.

Gas.

Baroda.

At the end of March 1922, Mr. H. C. Jones examined the borings which were being put down to prove the extent of the natural gas field at Baroda City. The late Captain R. W. Palmer made a preliminary examination of the area in 1921 (see General Report, *Rec. Geol. Surv. Ind.*, Vol. LIV, pp. 26-29), and very little progress with the boring operations had been made up to the time of Mr. Jones' visit. The cores of one of the

borings examined in Calcutta show that the rocks below the alluvium are mainly blue and grey calcareous clays, probably of Tertiary age.

Graphite.

Chitral.

Amongst the garnetiferous schists of the Barzin valley in Chitral, Mr. Tipper found a narrow band of graphitic schist. The material is crowded with minute garnets and hence is of no economic value.

Iron Ore.

N. Shan States ; Burma.

During the year under report Mr. E. L. G. Clegg was deputed to investigate some deposits of iron ore at the village of Kunghka in the Northern Shan States of Burma. The quarrying of this ore was commenced in 1916 by a Chinese contractor who carried the ore along a mule track 17 miles in length to Nam Tu, where it was used by the Burma Corporation for the fluxing of their silver, lead and zinc ores. After some prospecting work in the form of trenching carried out by the latter company, some 5,000 tons of ore were won. But as the prospects did not appear to be so good as were at first anticipated, quarrying had ceased at the time of Mr. Clegg's visit. The country is hilly and the deposit situated in the unfossiliferous Pang Yun series (see *Rec. Geol. Surv. Ind.*, XLVIII, page 145), which occupies a position between the Bawdwin Volcanics below and the fossiliferous Naungkangyis above, and is believed to be of either Cambrian or Ordovician age. At Kunghka the Pang Yuns consist of fine-grained, thinly-bedded, white and chocolate-coloured sandstones, micaceous shales, quartzites and occasional conglomerates. The ore-body occurs in a fault heading to the west and striking 15° west-of-north to 15° east-of-south. The fault is filled with lenticles and veins of solid hæmatite in a soft matrix of red and yellow limonite. In the matrix platy crystals of specular hæmatite are abundant, and also small nodules and veins of barytes, some of which show crystal intergrowth with the hæmatite. Lenticles of sandstone are also included and a passage is seen from the solid, slightly magnetic hæmatite, through highly ferruginous sandstones, to the hard, whitish quartziferous sandstones of the Pang Yun series. The outline of the ore-body is irregular. The iron ore, which is probably

derived from the Plateau Limestone originally overlying the Pang Yun series, has collected in the fault line as a result of the infiltration of iron-bearing waters. The hard "horses" of hæmatite and the soft earthy matrix occur in about equal quantities, the former yielding about 61 per cent. and the latter 47 per cent. of iron.

Manmaklang deposit.

Another area, from which iron ore had been extracted up to the early part of 1921, is that of Manmaklang, (Lat. 22° 50'; Long. 97° 40') in the Northern Shan States, 2 miles east of Manpwe and about 2½ miles from a new siding of the Burma Railways. The country rock is the Lashio Limestone, containing beds of sandstone. The shape of the deposit is unknown, but it is described as occurring in ledge-like masses and loose pebbles, beneath an overburden varying in thickness but averaging some 15 feet. The ore probably includes some hæmatite but consists mostly of limonite. The slimy character of the latter during the wet season was difficult to deal with and made the cost of working high. The Burma Corporation to whom I am indebted for most of the information regarding this area, worked this deposit for a short time, but their adit has fallen in and their "glory hole" become partially filled up with mud and water.

Kaolin.

Ratnagiri District: Bombay.

The occurrence of kaolin near Malvan in the Ratnagiri District of Bombay was investigated in April by Mr. H. C. Jones. The deposit, which is being worked to a small extent, is to be found in a small water-course about a quarter of a mile south of the village of Kumbharmatt (Lat. 16° 01'; Long. 73° 33') some three miles east of Malvan. The potters of the village have for a long time been making use of a soft micaceous material, consisting mostly of mica, kaolin and quartz, and termed by them *kup*; this mixture occurs as veins and patches in a layer of kaolin. The *kup* is mixed with an equal part of ordinary field or pottery clay, and is said to have the effect of preventing the pottery from cracking during the drying and firing process, and to give a certain toughness to the finished product. The *kup* and white kaolin are covered with some fifteen feet of hard laterite, through which a shaft has to be sunk; irregular tunnels are then constructed and these connected with the surface by additional shafts. The pits or shafts, which are about

twenty feet deep, fall in during the Rains, and at the time of Mr. Jones' visit only two were open; from these only a very approximate estimate of the deposit was possible. All the pits, whether functioning or abandoned, occur in a small valley and cover an area about a quarter of a mile in length and some 400 feet wide. The rocks, as shewn in neighbouring stream-beds, consist of hard gneisses and hornblende schists. Both the kaolin and *kup* are non-fusible at 1,400° C., do not crack on being dried, and yield a white brick. The kaolin appears to be of good quality, is slightly plastic, contracts on firing from 20 mm. × 10 mm. × 5 mm. to 19 mm. × 9 mm. × 4 mm., cracks slightly on being fired, yielding a hard and very slightly porous brick in which vitrification has just commenced. The *kup* is not plastic, suffers no contraction on firing and yields a soft friable brick. The laterite cap is a handicap to prospecting.

Lead.

Datia State.

The existence of a vein of galena in the Datia State of Central India has been known since 1875. During the year under report Mr. D. N. Wadia was deputed to visit and report upon the area. The vein traverses red ferruginous quartzites and sandstones of the Gwalior series near the village of Nardha, but is for the most part buried beneath alluvium. No estimate of the quantity of galena available is possible; the silver content is small. A short Miscellaneous Note on the occurrence is being published separately.

Manganese.

(See under "Copper.")

Mica.

Kodarma.

As a result of the recommendation by the Industrial Commission of 1916-18, Mr. G. V. Hobson was deputed during the year to inspect the mica mines of Kodarma in the province of Bihar and Orissa, with a view to seeing whether mining methods in practice pertaining to this industry were capable of improvement. Some difficulty was experienced in discovering the owners, and more particularly their local representatives, of the various mining concessions. Mr. Hobson considers

that, in the case of a mineral such as mica, where the product can be easily rough-sorted in the mine, and where no very great weight has to be transported to the factory, the question of roads is not so serious as in the case of other minerals; Mr. Tipper points out, however, that this question is of importance, in the case of machinery. A more efficient road scheme would, moreover, probably go some way towards stopping one of the greatest evils of mica-mining, *viz.*, thefts of mica. The geology of this area has been dealt with in detail in already published reports and need not be alluded to here. Mr. Hobson came to the conclusion that open-cast mining was unsuitable, but that the present system—if it can be called a system—should be much more regular than it is. This defect was pointed out by Sir Thomas Holland 25 years ago. In many mines the work follows the mica, all of which is removed when found, with the result that when barren ground is struck, there is no reserve to which attention can be turned. Production is in these cases a veritable hand-to-mouth affair. Mr. Hobson confirms Si Thomas Holland's conclusion also that overhand stoping might be found in many cases more advantageous than underhand.

One of the principal defects in the mica-mining of Kodarma is the absence of mine plans, in spite of the fact that the various leases include a clause which lays down that plans and sections of the mines shall be kept. Such plans and sections are hardly ever made. The serious aspect of this fact is that when workings are abandoned, no record exists of the extent and position of such workings, and the difficulty of mining such a deposit again, particularly if the old workings have since fallen in, is greatly increased. The only information available in such a case is hearsay evidence from men who have worked in the mine; this, it can be well imagined, is conflicting and quite unreliable. It is to be hoped that in future the clause in the lease alluded to will be rigorously insisted upon, and that proper mine plans will be constructed and kept up to date by all operators concerned.

Oil Shales.

Mergui District: Burma.

Some oil shales are reported by Mr. Vinayak Rao as occurring in the Theinbun valley of the Mergui District of Lower Burma. A miscellaneous note on the occurrence is being published in *Rec. Geol. Surv. Ind.*, Vol. LIV, pp. 342-343.

Petroleum.

Amherst District: Burma.

Some oil shales were discovered a few years ago in the Amherst District of Lower Burma, and the occurrence was investigated by Dr. Cotter in November and December 1921. These oil shales, which are the first to be observed in the Indian Empire, occur in synclinal basins of fresh-water Tertiary rocks containing fish remains and dicotyledonous leaves. The oil shale is distinguished from ordinary shale by its greater toughness and its ability to withstand a sharp blow from a hammer without splintering, by the fact that it can be cut into shavings with a knife without crumbling to powder, by its dark grey or brown colour, and especially by the peculiar smell given out when heated in a flame. Every grade of oil shale from rich to barren is to be found. Certain zones are reported to be sufficiently rich to warrant serious attention being given to their economic possibilities. It is hoped to publish a detailed accoun of these shales and their associated rocks towards the end of the year.

Padaukpin: Burma.

Dr. G. de P. Cotter was employed in August 1921 in a re-examination of the Padaukpin oilfield. The results of his observations have now been published. (*Rec. Geol. Surv. Ind.*, Vol. LIV, pp. 103-116).

Pakokku District: Burma.

Two new oil seepages are recorded by Sub-Assistant B. B. Gupta in the Pakokku District of Upper Burma, one in the Yebyu Chaung, about 1¾ miles west of Tandaw (Survey Sheet $84\frac{K}{5}$), and the other on a hill 1½ miles E.S.E. of Yonsin (Survey Sheet $84\frac{K}{6}$); both characterise the crests of anticlinal folds in the Pondaung Sandstone, and may prove worthy of further attention. Thick tarry oil was observed filling cracks and joint-places in a sandstone bed 1½ miles N.E. of Yonsin. Occurrences of bitumen and sulphuretted hydrogen were found in various places in sheets $84\frac{K}{5}$ and $84\frac{K}{6}$.

Salt.

Shwebo and Sagaing Districts: Upper Burma.

Since the greater part of the salt consumed in Burma is imported for that purpose, it is highly desirable to develope any resources of this mineral which the country may possess With this end in view Captain F. W. Walker was requested to visit the salt workings

in the Shwebo and Sagaing Districts. Salt works had already been established in the Amherst and Arakan Districts and had proved to be a complete success. The localities visited in Upper Burma lie between Sagaing and Shwebo close to the Mu Valley branch of the Burma Railway and are easily accessible. Four places where salt is being worked were visited, *viz.*, Halin, Thakuttaw, Sadaung, and Yega. The brine, which is thought to originate in Tertiary beds concealed beneath the alluvium, is considered to be sufficient in quantity and quality to warrant the encouragement of the industry. Between Thakuttaw and Halin, there are numerous small mud vents which seem to indicate fault line in the beds beneath. It is highly probable that such a line provided a means of escape for the brine. Captain Walker states that there is evidence of an actual stratum of salt, but a boring would do much to decide this point. It is hoped to publish a paper shortly giving more details of Captain Walker's investigations.

Sambhar Lake: Rajputana.

Before proceeding on leave in April Dr. Christie completed the analyses of brines from the Sambhar Lake in Rajputana. Samples had been regularly collected by the Northern India Salt Revenue Department at definite seasons from several fixed points in the area for a 10-yearly period, 1907-1916, according to a scheme devised by Sir Thomas Holland with the object of tracing changes in composition. Their investigation was delayed on account of more urgent questions connected with the war.

From the point of view of the salt manufacturer the results show a deterioration, the lake brine and the "subterranean" brine (*i.e.*, that collected from wells and canals dug in the lake bed) both having at the end of the period a lower percentage of sodium chloride in the total dissolved salts than they had at the beginning. The variations from season to season, from year to year, and from locality to locality, are considerable and, in many instances so far inexplicable. The mean value, however, for the latter half of the decennium shows a distinct depreciation in chloride content compared with that for the first half. The brines are essentially solutions of chloride, sulphate and carbonate, the metallic radicles being mainly sodium, with potassium, calcium, magnesium, etc., in subsidiary quantities. The results are given as the percentage of chloride (—Cl) in the sum of chloride (—Cl), sulphate ($=SO_4$) and carbonate ($=CO_3$); $Cl + SO_4 + CO_3$ being 100. In this way questions regarding the

combination of the radicles with one another are eliminated. The results may be summarised as follows :—

—	Lake Brine.	"Subterranean" Brine.
	—Cl. = SO_4. = CO_3.	—Cl. = SO_4. = CO_3.
1907-1911 mean	86·09 : 9·94 : 3·97	83 18 : 12·32 : 4·50
1912-1916 mean	85·38 : 10·84 : 3·78	81·07 : 13·88 : 5·05

The chloride figure for the lake brine has dropped from 86 09 for the first quinquennium, to 85·38 for the second, the corresponding figures for the "subterranean" brine being 83·18 and 81·07.

It is proposed to continue the periodic sampling of the brines on a system modified to suit somewhat extensive changes in the physical geography of the Lake, across which, towards its eastern end, a dam has recently been built to prevent the annual desiccation of a large area.

The mass of analytical data presents few features of general interest. To one of these, however, Dr. Christie calls attention, namely, the relationship between sulphate and carbonate. In the "subterranean" brines these two constituents vary directly, in the lake brines inversely, with respect to one another, indicating that the formation of the one product from the other- presumably the carbonate from the sulphate—is mainly a surface phenomenon.

Sillimanite.

Khasi Hills : Assam.

The occurrence of the mineral sillimanite in the Khasi Hills, Assam, has been demonstrated in a rather curious way. In March, 1908, the Deputy Commissioner of the Khasi and Jaintia Hills reported the discovery of corundum at Nongmaweit and other places, and specimens passed through the office of the Geological Survey on their way to Austria. As the samples were very small and scanty, none of them was broken or properly examined, and the Austrian consignee, when applied to for information, merely asked for larger samples. Amongst the material subsequently despatched there must evidently have been a certain amount of corundum, a small quantity of which mineral had been observed by Mr. LaTouche, who had searched this area in 1887. A Miscellaneous Note on the occurrence was

published in Vol. XXXVI, part 4, of the Records of this Department, including a remark that the "corundum extracted..........finds its way all over the hills for sale as hones." A reference was made to the presence of corundum (*mawshinrut*) at three localities in the Nongstoin State in the N. W. Khasi Hills in the Quinquennial Review of the Mineral Production for 1904—08[1], and in subsequent mineral reviews statistics of the amount extracted and its value were published as follows :—

1916	36,540	cwt. valued at	£2,555
1917	41,200	,, ,,	£3.799
1918	37.920	,, ,,	£3,862
1919	12.660	,, ,,	Rs. 47,475
1920	3,320	,, ,,	Rs. 2.151
1921	1,276	,, ,,	Rs. [illegible]

The figures shew that, as an abrasive, the Khasi mineral produced a war industry. In 1921, dissatisfaction expressed by purchasers in London at the lack of hardness of a consignment, led the European Agents of the Khasia Mines Co., Messrs. Pawle and Brelick to ask for a chemical and microscopic examination from Messrs. G. T. Holloway of Limehouse. The latter found over 35 per cent. of silica in one of the brands, which also shewed a hardness of only about 6½ instead of 9; Messrs. Holloway expressed the opinion that this sample consisted of sillimanite. Mr. C. S. Fox Assistant Superintendent of the Geological Survey of India, at ached to the Indian Trade Commissioner in London, was then consulted. He was able to confirm Messrs. Holloway's opinion that the material was mostly sillimanite and the rest a mixture in varying proportions of sillimanite and corundum. He pointed out at the same time that, as a refractory, especially for glass furnaces, sillimanite was of greater value than the abrasive corundum.

In 1922, Mr. F. W. Walker was deputed to make a brief examination of the deposits at Nongmaweit. Four "*in situ*" out-crops of sillimanite were found, as well as several boulder occurrences, the latter being the chief source of supply up to the present. The home of the material seems to be a pegmatite vein or veins, but the field evidence is very slight. The country rock consists mostly of biotite gneiss and quartz granulites, the latter being found in several of the tunnels constructed. Pure sillimanite occurs in long lath-shaped crystals of a white colour, with a pearly or greasy lustre but

[1] *Rec. Geol. Surv. Ind.*, Vol. XXXIX, p. 244.

a massive form is commonly found. The majority of the material, however, is composed of an altering sillimanite, and has a brown or steel-grey colour. Rutile occurs as an accessory, while other associated minerals include quartz, biotite, sericite, garnet and zircon. Sections from the sillimanite rock shew it to be composed of lath-shaped crystals of sillimanite arranged in radiating aggregates; a fibrous variety is very common.

The mineral sillimanite is a widely distributed one, but is found usually in small quantities only. It is known in Germany, France, Scotland, South Africa, Brazil, the United States, Burma and Ceylon. It is impossible to estimate the total quantity available in Assam until the loose "float" material has been removed, but the latter alone is of the order of 3,000 tons.

Soils.

Kyaukse: Upper Burma.

In April Dr. Cotter went to Kyaukse, Upper Burma, at the request of the Commissioner of Settlements, in order to examine, and if possible explain, the distribution of the soils known as *sa-ne* and *pu-tchi*. The latter is a variety of *regur* or cotton soil, while the former is a dark coloured clay soil. The present day distribution of these soils seems to be independent of the geology of the rocks beneath them. The cause of the peculiar distribution is obscure, but may be connected with the original distribution of forest and open country before the period when the country began to be tilled by man.

Sulphur and Sulphide Ores.

Chitral.

On the left bank of the Arkari, opposite the village of Mujhigram, a small deposit of sulphur contaminated by earthy matter was observed by Mr. G. H. Tipper. Sulphuretted hot springs are of common occurrence in the neighbourhood of the granite intrusions in the Chitral State, and Mr. Tipper is of opinion that the sulphur has been deposited from one of these springs. The deposit, although interesting, has no appreciable economic value. The sulphur has been used locally in the preparation of gun-powder.

The same observer found during his work in Chitral that a large area of the State of Chitral, on the borders of Afghanistan and

between the Lutkuh and Arkari valleys, is occupied by garnetiferous and other schists cut through by granite intrusions. At many places these schists contain patches of sulphides, chiefly pyrites and pyrrhotite accompanied by what appears to be löllingite, the arsenide of iron. The minerals weather out in nodules covered with a thick skin of iron oxides. The minerals have been tested for nickel with negative results. It would seem therefore that these mineral patches, which are generally small in extent, are of very little value.

Up the Barzin valley a narrow vein, one-quarter of an inch wide, of iron pyrites with a little copper pyrites, occurs in the granite. Incrustations of coppe· carbonates were noticed at other points near that locality.

Tin.

Mergui District: Burma.

Coarse stream tin was obtained by Rao Bahadur Vinayak Rao, by panning in the Ngawan River and its tributaries in the Mergui district of Lower Burma. Similar tin ore was also found in the Theinkun, and in Kisseraing Island.

Tungsten.

Mergui District: Burma.

Wolfram was found by Rao Bahadur Vinayak Rao in a pegmatite vein in the Tichyin Chaung, a tributary of the Theinkun in the Mergui district, close to the border of Siam. The same mineral occurs in the Mergui series of Pig Island.

Water.

Central Provinces.

Gurrah :—At the close of the field-season Mr. H. Walker visited the wells at Gurrah on the G. I. P. Railway near Itarsi. These large wells, two in number, are brick-lined and of the ordinary percolation type. A tube-well had been put down from the bottom of one of the wells, and water with a few feet of "head," had been obtained. Mr. Walker examined the material extracted from the boring, and found that it consisted of alternations of coarse sands and argillaceous bands and was evidently of the age of the Newer Narbada Alluvium. He

was able to assure the Engineers that good supplies of water could be expected from the coarse sands.

Jubbulpore : Central Provinces.

As the result of a request from the Central Provinces Government, Mr. H. Walker was deputed to report on the possibility of obtaining additional water supply for the municipality of Jubbulpore, in connection with a new sewage scheme for that town. A supply of 1,800,000 gallons *per diem*, not more than seven or eight miles from Jubbulpore, was desired. It had since been proposed to obtain this supply by conveying water by gravity pipe-line from the prospective Irrigation Reservoir on the Pariat River to the natural tank near the Robertson College. Mr. Walker, however, made a brief examination of the area and came to the following conclusions, which may be of use should the Pariat scheme fall through. The alluvium, Deccan Trap, Lameta beds and crystalline rocks are all either too thin or too impervious to provide the requisite quantity of water. In the Jubbulpore group, on the other hand, there is, underlying the pottery clay, a sandstone from which it is quite possible the required amount of water might be obtainable. This sandstone, though not thick, is known to bear water, and the prospects of tapping this amount by wells depend on whether the outcrop area and the thickness are sufficiently great to store it, and whether the faults which are known to be present allow any considerable proportion of it to escape. It is doubtful whether artesian conditions would be met with and some mechanical means of obtaining the water might be necessary. Mr. Walker is convinced that a well sunk in the Pachpedi valley, where the boundary of the Gun Carriage Factory Estate crosses the watercourse, would yield a good supply of water; unfortunately there seems to be no easy method of storage for the 48 hours reserve supply which Water-works Schemes dependent on machinery require. The scheme for impounding the water of the Pachpedi Nala is not to be recommended, as the flooded area would lie upon porous Jubbulpore sandstone; the retaining dam moreover would have to be built largely on these porous rocks, and would cross two faults which run in a general parallel direction to the stream. As an alternative to boring, the water of the Narbada might perhaps be utilized by sinking "filter-cribs" or "percolation-wells" into the river bed at some place below the junction of the Gaur tributary and pumping the water into the existing water-works reservoir.

GEOLOGIC SURVEYS.

Singhbhum : Bihar and Orissa.

During the field-season of 1921-22 the Bihar and Orissa and Central Provinces party consisted of Mr. E. Vredenburg (in charge), Messrs. H. C. Jones and J. A. Dunn and Sub-Assistant Durgashankar Bhattacharji. Mr. Jones continued the geological survey of the area to the south of Chaibassa, and for about two months was accompanied by Mr. Dunn who was being initiated into the local field geology. Mr. Dunn carried on the survey work in the area for about two months, after Mr. Jones had left for Kolhapur State. In the General Report for 1921, the sequence of rocks which Mr. Jones had worked out at the end of 1921 has been recorded, together with a description of the general relationship of these rocks. Mr. Jones continued the mapping of the boundaries and the elucidation of the relationship between these groups of rocks, but confined his attention more especially to the base of the Iron Ore series, where these beds rest unconformably on the Dharwars, and where they have been raised, penetrated and partly absorbed by the granite of central Singhbhum. The granite in parts has up-turned and caught up masses of the Dharwar rocks, and in places has penetrated into the basal purple conglomeratic sandstone of the Iron Ore series. The basal purple conglomeratic sandstone, for a distance of about ten feet from the granite, has been altered by contact metamorphism to a hard, pale grey or almost colourless rock, and in parts some of the conglomeratic sandstone has been absorbed by the granite.

Mr. Dunn spent the last two months of the field-season working mainly on the granitic rocks of the area. He found the granite cut up by innumerable trap dykes, some of which, when followed into the overlying shales of the Iron Ore series, were seen to spread out in the form of sills.

Sub-Assistant D. Bhattacharji's work lay in the Nagpur and Bhandara districts, where the chief structural feature proved to be a large synclinorium extending W.N.W through the Ambala tank.

Mergui District : Burma.

Rao Bahadur Vinayak Rao continued the geological survey of the Mergui district in Lower Burma. A traverse was made from Tenasserim along the Little Tenasserim River and the Theinkun to Prachuab Kirikan in Siam. The rocks consist chiefly of the Mergui argillites, phyllites and shales. There is a granite boss south of the broad valley of the Theinkun, while coarse-grained granite occupies the

main mass of the hill-range forming the boundary between Burma and Siam. On the Siamese side the granite extends to within 10 miles of the Gulf of Siam. The islands here, the principal of which is Ko Hlak, consist of crystalline and amorphous limestone.

Limestone crags, probably of the same age as the Tharabwin limestones, are found along the Ngawun, a tributary of the Little Tenasserim. In the valley of the Ngawun the Merguis were found conformably underlying the Moulmein limestones. Mr. Vinayak Rao reports that the former appeared to pass gradually upward into the latter. If this be so and the older rocks truly identified as Merguis, our ideas regarding the age of the Mergui beds, which have, up to the present, been thought to be the equivalents of the Chaung Magyi series of the Shan States, may require modification.

In the Mergui Archipelago, Domel Island forms a granite boss which has altered the Merguis in Kisseraing and the neighbouring islands.

Basaltic trap, which had been first noticed by Mr. C. Kitchin of Mergui, was found on the shore near Okpomaw and Medaw and fills up most of the low-lying ground. It appears to be of recent age, as it was found resting on laterite very similar to the laterite in the valleys of the Little Tenasserim and the Ngawun. There is evidence to show that the sea on the Siamese coast has retreated. and was in recent times at least 200 feet above its present relative level.

Tavoy.

Owing to a late arrival in Tavoy and an early withdrawal, due to work on the two Mount Everest expeditions, Dr. Heron's actual time in the field amounted to about two months only. Sheets $95\frac{L}{105}$, $95\frac{K}{4}$ and $95\frac{K}{8}$ were mapped on the scale of 1 inch to 1 mile, comprising Tavoy Island and the islands adjacent to it; on the Admiralty Chart of the Mergui Archipelago (scale approximately 4½ land miles to 1 inch) the islands between 97° 55′ and 98° 15′ longitude and between 12° 40′ and 11° 50′ latitude were examined, and two groups to the south of this were visited.

The Tavoy Island group consists of sedimentary quartzites, altered tuffs and quartz and felspar porphyry. The Birds' Nest Islands to the west (so called because they are the haunt of the swift which makes the edible nests of Chinese commerce) are of massive limestone (Moulmein).

Passing south towards Maingy Island, coarse volcanic agglomerates appear and the foci of the eruptions appear to be exposed on Maingy Island and in the west of Elphinstone Island. The

western coast of Elphinstone Island shows a great series of rhyolites and porphyries, and the high conical peaks on these islands are composed of volcanic agglomerates of the types usually found in and around volcanic necks, including fragments of pumice and devitrified glass, and pieces of various sedimentary rocks. Associated with these are dykes and small bosses of porphyritic microgranite and granites with large orthoclase phenocrysts in a granophyric groundmass, evidently hypabyssal types. Effusive rocks extend round the western coast of Elphinstone Island and the small islets off it, consisting of white tuffs, full of bombs and lapilli, felspar porphyries and cellular rhyolite (almost pumice) showing spherulitic structure. The large islands to the east of Elphinstone consist of the same rocks. The central portion of Elphinstone Island is occupied by coarse hornblende-biotite granite, differing from the normal type on the mainland in having hornblende in addition to biotite. The centre of Ross Island consists of the normal type of this granite, which probably occurs also on Grant's Island.

To the east and west of the Ross Island granite intrusion are Mergui sedimentaries, black slates and dark quartzites, partly volcanic in origin. The group of small islands south of Ross Island, extending from Warden's Island to Court's Island, are of similar mixed strata. The long line of islands, extending from the Pickwick group through Domel southwards to High Island, are of granite, which may be in submarine continuity with the boss of Ross Island. On Money Island, the granite is traversed by veins of a much weathered rock resembling basalt. Bentinck Island, Hastings' Island and St. Luke's Island were landed on and appear to consist largely of Mergui sedimentaries.

Tavoy and Amherst Districts : Burma.

Dr. Cotter, after visiting the Kanbauk and Hermyingyi mines and the tin-dredging locality of Taungthonlon in the Tavoy district, with the object of familiar sing himself with Tavoyan geology, examined in November and December the oil shales of the Amherst district. A summary of his results has been given in *Rec. Geol. Surv. Ind.*, Vol. LIV, pp. 29 and 53.

Loi-an : Southern Shan States.

In January and February 1922, Dr. Cotter, accompanied by Captain F. W. Walker, surveyed the Loi-an coal field near Kalaw in the Southern Shan States. Two formations characterise this area. The lower is the Plateau Limestone, which forms all the greater mountain

peaks and covers a large part of the country, while the upper is the Red Sandstone series, described by Mr. C. S. Middlemiss (General Report of the Geological Survey of India for 1899-1900, p. 122).

The Plateau Limestone is a grey, much crushed, dolomitic limestone, with traces of crinoids and other unidentifiable fossils. It is probably the Devonian or lower portion of the Plateau Limestone which is here exposed. It usually dips at steep angles (from 60° to 70°). Analyses show that about 20 per cent. of the rock consists of magnesium oxide.

The Red Sandstones, with which are associated the coal measures, are isoclinally folded and tucked away along fold axes in the limestones, and possess steep or vertical dips. The series is typically developed round Kalaw town, where red pebbly sandstones with frequent conglomerate bands are seen. The conglomerates consist of pebbles of grey limestone and of red sandstone in a red sandy matrix. This conglomerate is exactly similar to one which is found in the east of the Amherst district in Tenasserim. The coal-measures of Loi-an are separated from the red sandstones of Kalaw by a ridge of intervening limestone, and the relationship between the two is rather obscure, though it is probable that both groups are part of one series, the Red Sandstone series. The coal measures may be divided into a lower shaly zone, a middle zone in which sandstone predominates, and an upper zone containing coal seams. The roofs of the coal seams were frequently found to be fossiliferous, and a good collection of fossil plants was made by Dr. Cotter and Captain Walker; amongst them were the following species :—

Cladophlebis denticulata Brongn.
Gingkoïtes digitata Brongn.
Pagiophyllum divaricatum Bunb.
Brachyphyllum expansum Sternb.
Ptilophyllum sp., cf. *P. hislopi* Oldh.
Podozamites distans Morris.

This flora may belong to any part of the Jurassic or Rhaetic. The coal is therefore an Upper Gondwana coal, and thus differs from the remaining Burmese coals which are Tertiary. We may compare it with the coal of Tonkin, which probably comes from the same group. Further remarks on the coal will be found on page 14. In March Dr. Cotter paid a brief visit to the Minbu district to inspect the work of Mr. E. L. G. Clegg. In particular an examination of the 'Kyet-u-bok' bed, containing *Gypsina globulus*, *Orthophragmina*

omphalus and *Nummulites* (probably *N. yawensis*), was made. This bed was found to form a well marked horizon and to come stratigraphically upon the top of the Yaw stage.

Minbu district: Burma.

The survey of the Minbu district of Burma was continued by Mr. E. L. G. Clegg southwards from Mr. Sethu Rama Rau's work on sheet 84$\frac{L}{8}$. The main lithological feature is the increase in shale southwards in the Pegu series and in the Padaung Clays, Shwezetaw Sandstone, Yaw stage and Pondaung Sandstone. The Yaw stage ceases to form a marked feature south of the Salin-Sidoktaya road, and the Padaung Clays of the Ngahlaingdwin area were found to be below, and separated by a thin sandstone band from, the fossiliferous Padaung Clays of the type locality at Padaung. Evidence shewed that the Yaw stage fossil band, passing from north to south, had worked up into a higher stratigraphical horizon. The chief structural characteristic of the area is the presence of a series of synclines in the main range, faulted down against the Pondaung Sandstone, the strata in this way being duplicated.

Pakokku district: Burma.

During the season under review, Babu B. B. Gupta continued his previous work in the Pakokku district of Burma. The beds met with include the Axials, Laungshe shales, Tilin sandstones, Tabyin clays, Pondaung sandstones, Yaw shales, Pegu rocks and the Maw gravels. In the latter, near Ondaw, were found vertebrate remains of *Rhinoceros sivalensis*, *Sus titan* and *Mastodon* sp. Some interesting fossils were found in the Laungshe shales.

Betul district: Central Provinces.

The survey of the Betul district, Central Provinces, was continued by Mr. H. Walker assisted by Rao Bahadur S. Sethu Rama Rau. The area lying in the Tapti valley, from the crossing of the Betul-Ellichpur road westwards to the boundary of the district, contains Deccan Trap basalts, Infra-Trappean and crystalline rocks. The crystalline rocks, which are in the main granites or orthogneisses, are an extension of those found in the neighbourhood of the Betul civil station. Subordinate bands of schists were also found. The Infra-Trappean rocks, ranging in thickness from 10 to 80 feet and usually between 40 and 50 feet, are of sedimentary origin and pre-Trappean in age. The most important member is a grit, of thin to medium grain, lying upon which is nearly always found a narrow band of pebbly conglomerate. Similar conglomerate is seen at irregular intervals

throughout the thickness of the grit, often consisting of one layer only of pebbles ; the pebbles of the conglomerate invariably include some bright red jasper. The top of the series is formed by a thin argillaceous bed, usually red in colour, frequently removed by denudation or covered by débris. Mr. Sethu Rama Rau reports that this bed is frequently transformed into white or bluish-white porcellanite by the percolation of siliceous waters from the overlying trap. The grits are often similarly silicified. These Infra-Trappean rocks resemble neither the Lameta rocks of the Jubbulpur district nor the inter-Trappean rocks of the eastern parts of the Betul district. Mr. Walker is inclined to agree with Dr. W. T. Blanford that they are probably Mahadeva in age.

The Inter-Trappeans are only sparsely represented amongst the basalts of the Deccan Trap in this area. A few small isolated beds, varying from 4 inches to 2 feet in thickness, were found at two horizons, *viz.*, 100 feet and 150 feet respectively above the base of the Trap. Both horizons are siliceous, and in places contain silicified plant remains with *Physa principii* in addition in one locality. The upper horizon was found by Mr. Walker in the form of silicified residual blocks containing plant remains. The lower horizon is cherty, unfossiliferous and a few inches only in thickness.

The most interesting point in the geology of this area is the relationship which exists between the three main types of rock. Infra-Trappeans, lying horizontal, are found on the northern watershed of the valley and also in the bed of the river at least 500 feet below. In places the two exposures are connected by long gentle slopes of grits ; elsewhere, crystalline rocks are found between. These conditions have been brought about by faults which run east-by-north to west-by-south. The majority of these faults are, according to Mr. Walker, pre-Trappean in age, but cases have been noted in which the faulting took place in Trap times. The basalts of the Deccan Trap have taken advantage of the lines of weakness engendered by the faulting, which is represented now by dykes. There are undoubted cases of unconformity between the basalts and infra-Trappean grits due to pre-Trappean erosion. However, unconformity, in some places, has been traced to a fault, which has allowed the basaltic materials to well-out and spread over the surrounding rocks. The Tapti river, which rises near Multai in this district, first flows approximately south-by-west, but on entering this area follows a very sinuous course which for over 30 miles has a general

direction east-to-west. After leaving this area, it again flows to the south-west. In view of the faults which have been noted, it seems possible that this portion of the valley of the Tapti river is a large fault valley. Its course is approximately parallel to the great fault which is found at the south of the Betul district, and which leaves the basalts of the Bhainsdehi plateau 500 feet above the plains of Ellichpur and Amraoti.

Rao Bahadur Sethu Rama Rau, after completing the survey of the south side of the Tapti river valley, moved to the north-east of the district. He took up the work of delineation (on Degree Sheets Nos. 55 $\frac{J}{4}$ and $\frac{J}{8}$ of the one-inch Topographical Survey) of the Gondwana-Crystalline boundary. The Talchir stage consists of the usual greenish-purple conglomerates with pebbles of limestone, slate and granite, and of unfossiliferous shales. Amongst the Crystalline rocks of this part of the district, in addition to porphyritic-granites and augen-gneisses, impure crystalline limestones and calc-schists occur.

Chitral.

Mr. G. H. Tipper resumed his work in Chitral in 1923 and spent there the period from May to November.

It is not yet possible to write a connected account of the geology of the State as several gaps still remain to be filled. The section which is to be seen between the top of the Laorai pass and the Mirkanni fort continues to the south-west. The Mirkanni granite runs along both sides of the river and is well exposed in a series of gorges. In these gorges and in the side streams i is seen that the granite has been cut through by a number of dykes of basic rock often serpentinised, while a similar rock occurs as segregation patches in the granite itself. This association is continued along the Shishi Kuh, the valley which, as noted by Sir Henry Hayden, is the structural continuation of the Chitral river valley below Drosh. The Mirkanni granite appears to be intrusive into a series of unfossiliferous black slaty shales and altered limestones.

Between Mirkanni and Drosh the section is complicated by the occurrence of a much crushed calcareous conglomerate with which are associated red shale beds, overlain by a great mass of volcanic agglomerate. Sir Henry Hayden suggested that this conglomerate was perhaps the same as that of Reshun. This seems to be the case. This conglomerate runs the whole way along the Shishi Kuh, but the overlying beds are cut out by a fault and the whole thickness much

reduced. The Shishi Kuh has apparently been formed along this fault line. The *orbitolina* limestone discovered by Sir Henry Hayden, two miles below Drosh, has only been traced for a very short distance, and it is not yet clear what its relationship is to the rest of the section.

The exploration was not continued further to the north-east than the head of the Shishi Kuh. The Doko pass was crossed and the journey continued *viâ* the Golen Gol to the Chitral river, in order to follow up the Upper Devonian beds exposed near Shugram. While there further collections of fossils were made from the Upper Devonian.

In the gorge formed by the streams from Owir running into the Chitral river at Parpish, there is a section which appears to give a conformable sequence from the lower Devonian to the ***Fusulina*** beds. The lower Devonian is, as usual, faulted against the Reshun conglomerate of lower Tertiary or Upper Cretaceous age. There is a difference between the right and left banks, since on the latter the upper (***Fusulina***) beds are cut out by a dip fault. Followed along the strike to the south-west, the section continues, and good exposures with several well-marked fossil horizons are found on the track between Reri and Pasti. Near Pasti the upper (***Fusulina***) beds roll over and do not continue further, while the upper and lower Devonian still persist. In the neighbourhood of Partsan the structure becomes very complicated. The great fault, which brings the lower Devonian against the Reshun conglomerate, curves and describes almost a semi-circle before resuming its former direction. The curvature of the fault has been accompanied by the complex folding of the upper and lower Devonian and these are cut out.

Just north-east of Partsan, bands of crystalline limestone suddenly arise along the fault and come in between the lower Devonian and the Reshun conglomerate. Between Partsan and Shoghor these limestones attain a considerable thickness, while the conglomerate disappears. The presence of sections of *Hippurites* in the limestones near Partsan and above Shoghor shews that they are probably of middle Cretaceous age.

The Tirish Mir granite massif, which was only partly seen last year, has been fairly well delimited. The area, comprising the upper parts of the Lutkuh and Arkari valleys and forming the high ground between Afghanistan (Kufiristan, Badakshan and Wakhan), is cut through in every direction by a white, garnetiferous granite, intruded

into garnet schists, sillimanite and chiastolite schists and crystalline limestone bands, representing an altered sedimentary series. In places the intrusions are parallel to the foliation planes of the schists but often cut through at all angles, the final effect being to produce a breccia of schist and granite on a large scale, which has to be seen to be appreciated.

In the upper part of the Arkari valley there is only a small amount of intrusive material, and consequently the schists are much less metamorphosed and become comparatively soft, shaly beds. At a height of 16,000 feet, up the Nuqsan pass, a complete belemnite was discovered and fragments of two others at the foot. Although not specifically determinable, these fossils shew that these metamorphosed rocks in part are Mesozoic and probably Jurassic in age. It is, however, probable that the schists are not all of one age, as there are indications of crushed conglomerates in places. The whole area is extremely high, with peaks rising to 25,000 feet and many glaciers ; detailed work is practically impossible.

Hyderabad (Deccan).

During the field-season 1921-22, 858 square miles of the country west and south-west of the city of Hyderabad (Deccan) were geologically surveyed in detail by Mr. K. A. K. Hallowes. The area, which includes the famous city of Golconda, is composed mainly of biotite-granite gneiss, probably of Archæan age, without any associated schists. This gneiss is remarkably uniform in composition over large tracts, the biotite being very rarely replaced by hornblende to form hornblende-granite gneiss. Besides the uniformity of its composition, the biotite-gneiss is characterised by the presence within it of microcline, micro-pegmatite and micro-perthite, and occasionally cognate xenoliths : it is in all probability an orthogneiss. It is traversed by many east-to-west dykes of epidiorite, a rock suitable for road-metal. The gneiss is also intersected by many reefs of white quartz in which no signs of gold were observed ; these run in a direction north-to-south. Occasional veins of epidote, pegmatite, granite and quartz are to be observed.

The gneiss is covered in many places by Deccan Trap flows of basalt, varying in thickness from about 40 to 65 feet and containing inter-Trappean layers of brown or green chert, creamy white limestone, green earth with heulandite, and dark brick-red ferruginous bole. Mr. Hallowes made out some five different flows, of which the uppermost two are described as being decomposed into aluminous

laterite. Samples of the latter, on analysis, gave a percentage of alumina ranging from 10·40 to 30·54 per cent., and are not likely, therefore, to form a lucrative source of aluminium. The biotite-gneiss has been calcified and silicified by its junction with the basalt to form a white boundary bed, sometimes 10 feet in thickness. Mr. Hallowes records only one occurrence of true Lameta beds between the Deccan Trap and the Gneiss; they were met with in the form of a brownish white chert at a point a little under a mile W. S. W. of Chilkamari. The granite gneiss would furnish a strong durable building stone of good quality.

Punjab.

During the field-season 1921-22 Dr. Pilgrim was working in the extreme eastern part of the area which was examined by him, with the assistance of Mr. Vinayak Rao, during the season 1910-11. This embraces roughly that portion of the valleys of the Sutlej and its tributaries, which passes through Tertiary rocks and is included in the States of Belaspur and Nalagarh. Dr. Pilgrim has mapped in much greater detail than was done previously, and his more accurate observations have for the most part confirmed his previous conclusions as summarized in the General Report for 1910.[1] These need not therefore be repeated here, but certain particulars in which previous views have been modified or amplified may be briefly referred to.

The most valuable sections for correlation purposes were met with in the neighbourhood of Haritalyangar, from which locality Mr. Vinayak Rao had already collected fossils. Remains of vertebrates occur throughout a vertical distance of some 5,000 feet of strata, affording complete evidence for a conformable sequence from beds of Chinji age up to beds containing a typical Dhok Pathan fauna. This renders it possible for the first time to correlate the Lower and Middle Siwaliks of the Salt Range with those of the Himalayas by direct fossil evidence. It is hoped that these fossiliferous sections may be of still more importance in providing a clue to the classification of doubtful beds in other parts of the Himalayas.

Until now Dr. Pilgrim has classified the Nurpur red nodular clays with the Lower Siwalik,[2] but he now considers that it is more satisfactory to regard them as the basal beds of the Middle Siwalik, mainly because of the prevalence in them of the genus *Hipparion*, which is extremely scarce in the Upper Chinjis of the Salt Range.

[1] *Rec. Geol. Surv. Ind.*, Vol. XLI, pp. 82—84
[2] *Rec. Geol. Surv. Ind.*, Vol. XLI, p. 83.

The sudden lithological change in the Simla Hills from typical Nahan sandstones into beds composed chiefly of red clay renders the division one which can be easily distinguished and mapped. *Hyotherium chinjiense*, which is a characteristic Chinji species, has been found about 500 feet below this. About 1,500 feet above it occurs a well marked fossil horizon which appears to be identical with the Nagri zone, while some 3,000 feet above this again the Dhok Pathan zone can be recognized by a small but characteristic fauna. The latter beds underlie a great thickness of conglomerate, which is unfortunately unfossiliferous, but which may be lithologically identified with the Upper Siwalik. An unconformity between the two sets of beds is suspected.

Near Nalagarh convincing proof is claimed to exist of a gradual passage from the purple Dagshai clays and sandstones, through beds with fossil palm wood and a variety of *Mastodon angustidens* older than the Chinji form, up into beds of Chinji age (Nahan series). The fossil wood beds must be correlated with the Kasaulis or Kamlials or both. At Kundulu and many other localities these fossil wood beds are absent and strata which are in stratigraphical continuity with the Chinji horizon of Haritalyangar are described as resting with strong unconformity on the Dagshais. This unconformity is the most striking one in the whole system of freshwater deposits and evidently represents a period of considerable earth movement, resulting, according to Dr. Pilgrim, in the concentration of sedimentation into lake basins during the Kasauli stage. If this view can be definitely proved, Dr. Pilgrim considers it must raise doubts as to whether we can reasonably continue to classify the Kasauli stage with the Dagshais, or the rather indefinite Upper Murrees of Pinfold and other authors with the Murrees proper. Since, however, it is hoped that the mapping of the Simla Tertiaries will be completed during another field season, and in view of the fact that the present geological survey of Jammu may furnish relevant evidence, the question must remain for the present *sub judice*. Dr. Pilgrim was also able to visit the classic locality of Moginand at the base of the Siwalik Hills on the eastern bank of the Ghaggar. He has no doubt that he has at last identified the sites from which the early collectors obtained so many of their specimens. The value of this discovery lies especially in the fact that it is now clear that beds with *Elephas planifrons*, *Equus* and *Camelus* occur about 5,000 feet below the base of the Boulder Conglomerate zone, and

cannot be far above the base of the Pinjor zone. The occurrence of *Equus* and *Camelus* at this horizon supports Dr. Pilgrim's latest opinion that the Boulder Conglomerate zone of the Siwaliks is Pleistocene.

The Punjab and Poonch.

Mr. D. N. Wadia continued the survey of the Rawalpindi area, connecting up the isolated surveys made by the present writer.

In Poonch the Siwalik basin forms a deep circular embayment within the main boundary line of the Murrees east of the Jhelum. It forms the northernmost limit of the Siwalik deposits, which here attain the unusual altitude of 7,000 feet, comprising the soft micaceous sandstones of normal Siwalik type associated with harder and more compact nodular shales and clays, recalling the Murree series. It is possible that Upper Murree, or Kasauli beds, may be present in the crests of some of the anticlines. On the whole, the Lower Siwaliks evince a preponderance of the Kamlial facies over that of the Chinji. The Middle Siwaliks are thinner, but spread over a considerably large area of the Siwalik basin. Upper Siwaliks have not yet been found in Poonch. In the anticlinal crests of Palandri three gas-seepages were found, but the structure is unfavourable for any considerable storage of oil. The suggestion of the present writer in his Memoir on the Oil Occurrences in the Punjab that the whole western border of the Pir Panjal from Mozafferabad to its south-eastern extremity near the Ravi is of Nummulitic (Subathu) age, was confirmed by Mr. Wadia's discovery of nummulites and other foraminifera.[1] These beds were classified by Lydekker under the name of Kiol series, afterwards changed to Kuling. Lydekker regarded them at first as probably Silurian and perhaps partly Carboniferous, but coloured them on his map as doubtful Trias; later he regarded them as Permo-Carboniferous. Groups "b" and "c," however, from the position and description of their character, the present writer was strongly inclined to assign to the Nummulitic series—a series to which they were originally attributed by their discoverer, Colonel (then Major) Godwin Austin. The limestones occur precisely where the Nummulitic had been found west of the Jhelum and around Mozafferabad, and contain masses of bitumen, coaly shales and nodular iron-ore. The discovery of nummulites now changes this suggestion to a fact and Lydekker's classification will require modification. This Tertiary belt in the Pir Panjal is separated by a thrust fault from a

[1] *Mem. Geol. Surv. Ind.*, Vol. XI, p. 439.

wider belt of phyllites and schists associated with graphitic slates and quartzites. The age of the latter is uncertain, but may perhaps be Purana. Overlying both the Tertiary and the older zone at irregular intervals are thick masses of Panjal Trap.

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INDIAN TERTIARY GASTROPODA, NO. 5, FUSIDÆ, TURBINELLIDÆ, CHRYSODOMIDÆ, STREPTURIDÆ, BUCCINIDÆ, NASSIDÆ, COLUMBELLIDÆ, WITH SHORT DIAGNOSES OF NEW SPECIES. BY THE LATE E. VREDENBURG, B.SC., A.R.C.S., *Superintendent, Geological Survey of India.* (With plates 1 to 5.)

THE present instalment constitutes a continuation of the notices on Indian Tertiary Gastropoda published in previous numbers of these Records.[1]

As in the list last published[2] the fossils figured in the present notice are partly from Burma and partly from the Ranikot beds of Sind. Most of the Burmese localities dealt with in the previous numbers have contributed species to the genera dealt with in the present list. The previously published contributions may be consulted to ascertain their geographical bearings and geological horizons. To them must be added Shinmadaung hill (21° 34′, 95° 6′), in the Pakkoku district in the neighbourhood of which I obtained the *Melongena* figured in Plate IV, from beds containing the typical fauna of the Sitsayan or Padaung stage of Middle Oligocene age. *Clavilithes songoënsis* Martin (*see* below, p. 55) originally described from the Upper Eocene of Java, was obtained by S. Sethu Rama Rau at a spot situated 4 miles W. N. W. of Ngapya village (20° 56′, 94° 24′) in the section exposed along the banks of the Thayetkon chaung, amongst beds yielding the fauna of the Yaw stage of Upper Eocene age.

A most important occurrence of Lower Eocene fossils in the Burmese Tertiary has lately come to light as the result of Mr. Bankim Behari Gupta's investigations in the Pakkoku district. At a spot situated 1½ miles south of Yeshin (21° 52′, 94° 8′), the lower beds of the Laungshe shales which occupy a low level of the Eocene in Mr. Cotter's scheme of classification, have yielded a gastropod fauna amongst which several species are sufficiently preserved for specific identification, and have been quite correctly determined by Mr. Gupta as corresponding with *Athleta Noetlingi* C. and P., *A. Eugeniæ* Vred., and *Strepsidura indica* C. and P. from the Upper Ranikot of Sind. *Athleta Eugeniæ* occurs, in Sind, in zones 3 and 4,

[1] *Rec. Geol. Surv. Ind.*, Vol. LI, pp. 339—361, Vol. LIII, pp. 83—141, Vol. LIV. pp. 243—276.
[2] *Rec. Geol. Surv. Ind.*, Vol. LIV, pp. 244—245.

the two other species range from zones 2 to 4.[1] There cannot be the slightest doubt that the lower horizons of the Laungshe Shales include the equivalents of at least the uppermost zone of the Upper Ranikot of Western India. At a horizon situated stratigraphically about 180 feet below the bed containing the Ranikot fossils of Yeshin, Mr. Gupta obtained a gastropod which he has identified as a *Cinulia*, an *Orbitoides* closely related to *O. apiculata* Schlumb., if not specifically identical and other badly preserved fossils of Cretaceous facies. The Laungshe Shales at higher horizons, contain a nummulite identical with the form which I call *N. atacicus*, which characterises the Laki stage (essentially equivalent to the Lybian of Egypt) in various parts of India.

In Mr. Cotter's scheme of classification of the Eocene of Burma, the Laungshe Shales are followed successively by the Tilin Sandstone, the Tabyin Shales, the Pondaung Sandstone and the Yaw stage. Mr. Cotter's investigations, both amongst the vertebrates and invertebrates, have established the Upper Eocene age of the two upper subdivisions. It is now evident that the Laungshe Shales coincide essentially with the Laki stage of Western India, and extend downward into the equivalent of at least the uppermost zone of the Upper Ranikot. The equivalents of the Khirthar (Lutecian) of other parts of India must then be looked for amongst the Tilin Sandstone and Tabyin Shales.

The Yeshin occurrence thus supplies a clue for at least a rough approximation to a scheme of equivalence of the Burmese Eocene.

Mr. Gupta's discovery moreover definitely relieves the Ranikot fauna of the isolation from which it apparently suffered hitherto. However much it may differ from contemporaneous Lower Eocene faunas in Europe, we know now for certain that it has a wide extension in an eastern direction.

Genus: FUSUS Klein 1753.

The following species of *Fusus* are known in a fossil condition from the Tertiary formations of India :—

1. *Fusus perplexus* Adams (Cossman, 1903, *Journ. Conch.*, Vol. 4, p. 125, Pl. IV, figs. 17, 18). Tertiary formation of Karikal.

[1] The locality Yeshin must now be added to the list of occurrences of the two species *Athleta Noetlingi* C. and P., and *A. Eugeniæ* Vred., given in *Recs. Geol. Surv. Ind.*, Vol. LIV, pp. 257 and 260, for they were only known hitherto from the Ranikot beds of Sind.

2. ***Fusus*** *Humei* n. sp.
3. „ *promensis* n. sp.
4. „ *buddhaicus* n. sp.
5. „ *jhirakensis* C. and P. (*Pal. Ind.*, new ser., Vol. III, Mem. 1, p. 30, Pl. III, figs. 17, 18). Lower Eocene of Sind.
6. „ (*Pagodula*) *colpophorus* C. and P. (*Pal. Ind.*, new ser., Vol. III, Mem. 1, p. 31, Pl. III, figs. 27, 28, Pl. VII, fig. 50). Lower Eocene of Sind.
7. „ (*Aptyxis*) *reticulatus* Vred. Nari of Sind.

FUSUS HUMEI n. sp.

Pl. III, fig. 3.

This shell exhibits the closest resemblance to the recent *Fusus longicauda* Bory, living along the coasts of India and Ceylon, of which it may perhaps be regarded as an ancestral premutation. The living shell differs principally by its thicker and wider-spaced spiral threads, and does not exhibit the slight concave circum-sutural constriction that characterises the fossil.

Occurrence.—Payagyigon.

FUSUS PROMENSIS n. sp.

Pl. II, fig. 3.

This shell seems to be very closely related to *Fusus gradatus* Reeve, from the West Indies, which grows to a somewhat larger size.

Occurrence.—Thanga.

FUSUS BUDDHAICUS n. sp.

Pl. II, fig. 7.

This form is represented, up-to-date, by a single specimen, on the columella of which it has not been possible to ascertain whether folds are present or not. The ornamentation recalls that of *Lathyrus indicus* to be dealt with hereafter. Nevertheless, the much shorter, broadly conical spire gives it such a different appearance that it must be regarded as specifically distinct. The shortness of the spire relatively to the total height of the shell would be a most exceptional feature in a *Lathyrus*, and this form may therefore be

provisionally classified as a *Fusus*, a generic determination also suggested by the straightness of the columella. The general shape is not unlike that of a *Clavilithes*, but the small protoconch, the posteriorly vertical columella, and the gradual slope of the neck are more in keeping with *Fusus*.

Within the genus *Fusus*, the shortness of the spire readily distinguishes this form from other nodose species, both fossil and recent. *Fusus gothicus* Desh., from the Paris Eocene, has a somewhat similar shape, but without the broad ribs.

Occurrence.—Tetma.

Genus: CLAVILITHES Swainson 1840.

The following species are known from the Tertiary formations of India:—

1. *Clavilithes leilanensis* n. sp.
2. ,, *songoënsis* Martin. W. N. W. of Ngapya, Yaw stage.
3. ,, *Cossmanni* n. sp.
4. ,, *seminudus* [Noetl.] (*Rec. Geol. Surv. Ind.*, Vol. LI, p. 286). Dalabe; Kyaungon; Minbu, "zone of *Cancellaria martiniana*"; Mindegyi; Myaukmigon; Myaungu, lower horizon; Ngahlaindwin; Singu, "F", "N", "P";[1] Thanga; Thayetmyo, "zone of *Aricia humerosa*"; Tittabwe; Yenangyat, "zone of *Paracyathus caeruleus*."
5. ,, *Verbeeki* Martin, Mekran beds.
6. ,, *inopinatus* [Cossmann].
7. ,, *arakanensis* n. sp.

CLAVILITHES LEILANENSIS n. sp.

Pl. V, fig. 1.

In spite of its very incomplete condition, this shell exhibits such clearly distinctive features that it has been considered useful to record it, especially as it helps to give a correct idea of the general facies of the Ranikot fauna. A restored outline is shown in figure 1, Plate V. The shell is particularly remarkable for its very large size. *Clavilithes maximus* [Desh.], from the Lutecian of the Paris region, exceeds it in length, but not in width; the European species

[1] See *Rec. Geol. Surv. Ind.*, Vol. LIII, pp. 327, 328.

being distinguished from the Indian shell by a much more cylindrical body-whorl, and much more stepped or terraced spire. *Clavilithes conjunctus* [Desh.], also from the Lutecian of the Paris region, resembles *C. leilanensis* in shape though it has a more rapidly contracted base, but its dimensions are much smaller.

Occurrence.—Upper Ranikot. Zone 2, higher beds: three miles east of the old coal-pit near Leilan, Vera plain, east. (Fedden, G. $\frac{280}{126}$).

CLAVILITHES COSSMANNI n. sp.

Pl. III, figs. 1, 2; Pl. V, fig. 2.

Although closely related to *Clavilithes songoënsis* Martin which occurs in the Upper Eocene both of Java and Burma, the shell here recorded as *Clavilithes Cossmanni* is clearly distinguished by a number of well-marked differences. At equal dimensions of growth, the circumsutural expansion of *C. Cossmanni* becomes incomparably wider and the spire-whorls acquire a depressed cylindrical shape quite different from that observed in *C. songoënsis.* The later spire-whorls also lack the shallow concave constriction anterior to the external bounding angulation of the circumsutural expansion which is observed in *C. songoënsis.* While the characters of *C. songoënsis* remain relatively constant with increasing growth, the circumsutural rim in *C. Cossmanni* continues expanding proportionately faster than the corresponding growth of the shell. In the absence of any connecting gradations, the fossil under consideration must therefore be regarded as specifically distinct from *C. songoënsis.*

Occurrence.—Kyudaw Chaung.

CLAVILITHES INOPINATUS [Cossmann].

1903. *Euthriofusus inopinatus* Cossmann. *Journ. Conch.*, Vol. L, p. 126, Pl. IV, fig. 20.

This shell, originally described from the Pliocene of Karikal, is very closely related to *C. seminudus* Noetl. of which it may be taken to represent the persistence of juvenile characters up to a size at which *C. seminudus* invariably exhibits adult characters of outline, irrespective of the presence or absence of the final callosity. The persistence of the axial ribs throughout the spire, the shortness and spheroidal outline of the convex portion of the body-whorl, the persistence of prominent spiral threads on the middle part of that

convexity, the prominence and relatively wide spacing of the spiral ornaments throughout the whole length of the anterior stem, readily distinguish this shell from specimens of the same size of *C. seminudus.*

Occurrence.—Karikal, Kyudawon.

CLAVILITHES ARAKANENSIS n. sp.

Pl. I, fig. 9.

This shell is quite different from the other Indian species of *Clavilithes.* It recalls *Clavilithes striatus* Bellardi, from the Miocene of Piedmont, but is much more elongate.

Occurrence.—Ngahlaindwin.

Genus : EUTHRIOFUSUS Cossmann 1901.

The following species of *Euthriofusus* are known from the Tertiary formation of India : –

1. *Euthriofusus subregularis* [d'A. and H.]. Nari of Sind.

1*a*. ,, *subregularis* var. *narica* Vred. Nari of Sind.

2. ,, *Alompræ* n. sp.

3. ,, ? *Malcolmsoni* [d'A. and H.] (Descr. an. foss. gr. numm. Inde, p. 308, Pl. XXIX, figs. 17, 18). Eocene of Subathoo.

4. ,, ? *obscurus* [d'A. and H.] (Descr. an. foss. gr. numm. Inde, p. 309, Pl. XXIX, fig. 19). Eocene of Subathoo.

The two species last named are only known in the condition of internal casts, and their generic attribution remains, consequently, doubtful.

EUTHRIOFUSUS ALOMPRÆ n. sp.

Pl. 1, fig. 1.

This shell exhibits an extraordinarily close resemblance to *Euthriofusus virginens* Grateloup from the Miocene of France and Italy. The sutures in the Indian fossil are more constricted, principally on account of the contraction of the anterior part of the whorls which, in the European fossil, is practically vertical. The general outline of the spire, in the European form, shows a very slight

tendency towards a conoidal shape, while there is an equally slight tendency towards an extraconic shape in the Indian fossil. The Burmese fossil does not share the dimorphism of individuals nor the dimorphism of growth of the spire exhibited by *Euthriofusus subregularis* [d'A. and H.] from the Oligocene of Sind which it nevertheless closely resembles. In the Burmese shell, moreover, the ribs are slightly more sinuous than in *E. subregularis*.

Occurrence.—Payagyigon.

Genus : STREPTOCHETUS Cossmann 1889.

The following species of *Streptochetus* are known from the Tertiary formations of India :—

1. *Streptochetus* ? sp. indet. (Cossmann and Pissarro, *Pal. Ind.*, new ser., Vol. III, Mem. 1, p. 32, Pl. III, figs. 19, 20). Lower Eocene of Sind.
2. ,, *pseudowæli* Vred. Nari of Sind.
3. ,, ? indet. (d'Archiæ and Haime, Descr. an. foss. gr. numm. Inde, p. 308). Gáj of Sind.

Amongst these forms, the generic attribution of those first and last named is uncertain. The genus is not represented in the Tertiary fauna of Burma.

Genus : FASCIOLARIA Lamarck 1801.

The genus *Fasciolaria* is doubtfully represented in the Tertiary of India by the following species :—

Fasciolaria (*Pleuroploca*) ? *læviuscula* J. deC. Sow. Gáj of Kachh.

Genus : LATHYRUS Montfort 1810.

The following species of Lathyrus are known from the Tertiary of India :—

1. *Lathyrus* ?, sp. indet. (Cossmann and Pissarro, *Pal. Ind.*, new ser., Vol. III, Mem. 1, p. 33, Pl. III, figs. 15, 16). Lower Eocene of Sind.
2. ,, *sindiensis* Vred. Oligocene of Sind.

2a. ,, ,, var. *birmanica* n. var.

3. ,, *indicus* Vred.
4. ,, *pseudolynchoides* n. sp.
5. ,, *iravadicus* n. sp.

6. *Lathyrus ? duplicatus* Vred. Mekran beds.
7. „ *(Peristernia) Gautama* [Noetl.].
8. „ *(Peristernia) promensis* n. sp.

LATHYRUS SINDIENSIS Vred. var. BIRMANICA.

In all essential characters, the specimens of this form agree with *Lathyrus sindiensis* from the Oligocene of Sind, from which they differ only in some minor details of the ornamentation. The number of principal spiral threads on the spire-whorls is only three or four, instead of four or five as in the Sind form. These primary threads maintain their preponderance over the intercalary threads at all stages of growth far more prominently than in the Sind form. The threads of the second order being much thinner than those of the first order, allow ample space for the development of threads of a third order which often become distinct at a relatively early stage of growth and may even become duplicated. The spire-whorls are slightly more contracted anteriorly than in the type form.

Much hesitation has been felt as to whether the type form from Sind should be separated specifically from *Lathyrus retrorsicosta* [Sandberger] from the Mainz Tertiary formation. The Burmese specimens, by the preponderance of their principal threads, are even nearer related to the European form than those from Sind. Nevertheless, they are likewise distinguished by the presence of three columellar folds instead of two.

Occurrence.—Payagyigon, Tetma.

LATHYRUS INDICUS Vred.

Pl. I, fig. 3.

1895. *Fasciolaria nodulosa* Sow. *sec.* Noetling (*pars*).—*Mem. Geol. Surv. Ind.*, Vol. XXVII, p. 34, Pl. VIII, figs. 1, 2 (*non* fig. 3).

1901. *Fasciolaria nodulosa* J.deC. Sowerby *sec.* Noetling,—*Pal. Ind.*, new ser., Vol. I, part 3, p. 314, Pl. XX, fig. 16, Pl. XXI, fig. 1 (*non* Pl. XX, fig. 17).

1921. *Lathyrus indicus* Vredenburg.—*Rec. Geol. Surv. Ind.*, Vol. LI, pp. 272, 287.

This species has already been discussed in a previous volume of these Records (*loc. cit. in syn.*). The illustrations here published are intended to supplement the unsatisfactory figures in Noetling's monograph.

Occurrence.—Minbu, "zone of *Cancellaria martiniana*"; Payagyigon; Tetma; Yenangyat, "zone of *Paracyathus caeruleus*."

Lathyrus pseudolynchoides n. sp.

Pl. I, fig. 6.

This shell has the appearance of a reduced replica of *Lathyrus lynchoides* Bellardi (Moll. teir. terz. Piem. e Lig., IV, p. 18, Pl. I, fig. 5) from the Miocene of Europe from which it is distinguished principally by its smaller size. The axial ribs are fewer in the Burmese than in the European shell.

Occurrence.—Myaukmigon, Thanga.

Lathyrus iravadicus n. sp.

Pl. I, fig. 2.

The modern fauna of the eastern seas does not appear to contain any forms closely related to this species. Amongst Atlantic species *Lathyrus attenuatus* Reeve and *Lathyrus filosus* Schubert and Wagner bear some resemblance to the Indian fossil, but are distinguished by lower, broader whorls.

Compared with *Lathyrus sindiensis*, *L. iravadicus* is distinguished by a shorter spire, somewhat more convex spire-whorls, a less abruptly convex base, and flatter, broader, less sharply defined columellar folds.

Occurrence.—Dalabe, Thanga.

Lathyrus (Peristernia) Gautama [Noetling].

1901. *Persona Gautama* Noetling.—*Pal. Ind.*, new ser., Vol. 1, part 3, p. 305, Pl. XX, figs. 6, 7.

1921. *Lathyrus (Peristernia) Gautama* Noetling.—Vredenburg, *Rec. Geol. Surv. Ind.*, Vol. LI, pp. 270, 287.

This interesting species was originally described by Dr. Noetling from Theobald's Kama collection where it is represented by some crushed and distorted specimens which conveyed an erroneous impression regarding the mode of growth of the shell. The posterior channel of adult specimens is thickened to an extent which is exceptional but not abnormal, and the growth of the shell, as illustrated by the specimens now available, is remarkably regular, in accordance with the generality of the Fusidæ, and does not in any way recall that of *Persona*. The columella, indistinctly preserved in the original type, is undoubtedly that of a *Peristernia*.

Amongst the numerous living species of *Peristernia*, *Lathyrus Belcheri* [Reeve] shows some resemblance in general outline, but is not sufficiently closely related to require detailed comparison. *Lathyrus Forskalii* Tapparone, from the Red Sea, regarded by Tryon as a variety of *Turbinella nassatula* Lam. the genotype of *Peristernia*, shares the elongate spire and short canal of the above-described shell, but lacks its angulation while it has much more crowded ribs.

Lathyrus nangulanus Martin (*Samml. des geol. Reichs-Mus. in Leiden*, Ser. 1, Vol. III, p. 107, Pl. VI, fig. 107), a fossil from the Tertiary beds of Java, slightly resembles *Lathyrus Gautama* in general appearance, but is readily distinguished by its longer canal, while the spire appears somewhat less elongate.

Occurrence.—Kama, Kyaungon, Myaukmigon.

LATHYRUS (PERISTERNIA) PROMENSIS n. sp.

Pl. I, fig 4.

Taking into consideration the great variability of many species of *Peristernia*, it might perhaps be regarded as possible that the shell under consideration is only a variety of *Peristernia Gautama*. Nevertheless, *P. Gautama* is known from several localities in each of which it exhibits very constant characters, none of the specimens showing any tendency to assume the characters of *P. promensis* though the solitary specimen of the latter was obtained in the same strata in one of the localities yielding *P. Gautama*. For the present, therefore, the two forms must be treated as specifically distinct, the one at present under consideration differing from *P. Gautama* by its smaller size, its vertically much more compressed outline, its much broader somewhat stepped spire with a well marked angulation from the earliest stages of growth.

It so closely resembles certain forms of *Lathyrus nassatula* [Lam.] from the Indo-Pacific region, the genotype of *Peristernia*, that it may possibly be regarded as an ancestral premutation, the recent form being distinguished by its larger size and somewhat coarser spiral decoration. The same differences distinguish *Lathyrus Philberti* Recluz, from the Philippines, also very closely related to the fossil under consideration. *Lathyrus australiensis* Reeve is also very similar, but is also larger, with a more even spiral decoration.

Occurrence.—Myaukmigon.

Family TURBINELLIDÆ.

Genus: TURBINELLA LAMARCK 1799.

The following species of *Turbinella* are known from the Tertiary formations of India :—

1. *Turbinella episoma* Michelotti. Nari of Sind and Baluchistan. Also occurring in the Oligocene of Liguria.
2. „ *affinis* J. de C. Sow. Lower Gáj of Kachh, Sind, and Kathiawar.
3. „ *præmekranica* Vred. Upper Gáj of Sind.
4. „ *mekranica* Vred. Talar stage of the Mekran beds.
5. „ *pirum* Linnæus (=*T. rapa* Gmelin: (Cossmann, 1903, *Journ. Conch.*, Vol. L, p. 130). Pliocene of Karikal.

The genus is not known from the Tertiary of Burma.

Genus: VASUM Link 1807.

The following species is the only one at present known from the Tertiary of India :—

Vasum basilicum [Bellardi] (*Rec. Geol. Surv. Ind.*, Vol. LI, pp. 273, 287). Singu "P.";[1] according to Nœtling "Singu, zone of *Mytilus nicobaricus*."

Genus: TUDICULA Link 1807.

The following is the only species at present known in a fossil condition from the Tertiary formations of India :—

Tudicula spirillus [Linn.] (Cossmann, 1903, *Journ. Conch*, Vol. L, p. 127, Pl. IV, fig. 19). Pliocene of Karikal.

Genus: MELONGENA Schumacher 1817.

The following species of *Melongena* are known from the Tertiary formations of India :—

1. *Melongena præmelongena* n. sp.
2. „ *cornuta* Agassiz. Gáj of Kachh.
3. „ *pseudobucephala* Nœtl.

[1] See *Rec. Geol. Surv. Ind.*, Vol. LIII, p. 327.

4. *Melongena acanthina* [Dalton]. (*Rec. Geol. Surv. Ind.*, Vol. LIII, p. 84). Myaungu (lower horizon), with two rows of spines; Singu, "P", with four rows of spines; Yenangyat, "P", with three rows of spines; also, according to Dalton, 1½ miles north of Lanywa, Pakokku district, apparently with three rows of spines.
5. ,, *Lainei* Basterot. Gáj of Kachh and Sind.
6. ,, *galeodes* Lam. var. *sindiensis* Vred., Gáj of Sind.
7. ,, (*Pugilina muriciformis* [C. and P.]
8. ,, (*Pugilina*) *præparadisiaca* n. sp.
9. ,, (*Pugilina*) *Junghuni* Martin (*Samml. d. geol. R.-Mus. in Leid*, new ser., Vol. I, p. 94, Pl. XX, figs. 302-304). Minbu, high horizon (Miocene).
10 ,, (*Pugilina*) *Ickei* Martin.
11. ,, (*Pugilina*) *præponderosa* Vred. (*Rec. Geol. Surv. Ind.*, Vol. LI, pp. 273, 287). Minbu: Prome "zone of *Cytherea erycina*"; Singu, "L";[1] Tetma; Tittabwe.
12. ,, (*Pugilina*) *ponderosa* Martin (*Samml. d. geol. R.-Mus. in Leid.*, new ser., Vol. I, p. 92, Pl. XIV fig. 208). Talar stage of the Mekran beds.

MELONGENA PRÆMELONGENA n. sp.

Pl. IV.

This shell is evidently a premutation of the recent *Melongena melongena* Linn. from which it is distinguished by its vertically more contracted shape.

Occurrence.—Shinmadaung, Minbu stage.

MELONGENA PSEUDOBUCEPHALA Nœtl.

1901. *Pyrula bucephala* Lamk. *sec.* Nœtling (pars). *Pal. Ind.*, new ser., Vol. I, part 3, p. 317, Pl. XXI, fig. 3 (*non* fig. 4 = *Vasum basilicum* [Bellardi]).

1901. *Pyrula pseudobucephala* Nœtling.—*Pal. Ind.*, new ser, Vol. I, part 3, p. 318, Pl. XXI, figs. 5, 6.

1921. *Melongena pseudobucephala* Nœtling.—Vredenburg, *Rec. Geol. Surv. Ind.*, Vol. LI, pp. 273, 274, 287.

The name bestowed upon this fossil is not very appropriate for it is not closely related to *Melongena bucephala* Lamk., which is readily distinguished by its short spire and its prominent prong-

[1] See *Rec. Geol. Surv. Ind.*, Vol. LIII, pp. 326—327.

shaped spines. It corresponds very closely with *Melongena cornuta* Ag., from the Miocene of Europe and Western India, from which it is distinguished by its more elongate spire and by the more conical shape of the anterior portion of the body-whorl which, in *M. cornuta*, exhibits, at the base, a distinct though not pronounced concavity of which there is no indication in the Burmese fossil.

Occurrence.—Singu "P";[1] according to Nœtling "Singu, zone of *Mytilus nicobaricus.*"

MELONGENA (PUGILINA) MURICIFORMIS [C. and P.].

Pl. V, fig. 3.

1909. *Genotia muriciformis* Cossmann and Pissarro.—*Pal. Ind.*, new ser., Vol. III, Mem. 1, p. 16, Pl. II, figs. 1, 2.

In the work quoted above, this shell was tentatively classified as a *Genotia* on account of the sinuosity of the lines of growth on the posterior slope, although the authors particularly noticed that the fossil has the appearance of a *Melongena*. This character is probably not infrequent amongst Eocene species of *Melongena*. Amongst the fossil species available in the Calcutta Museum, the specimens of *Melongena minax* [Solemd.] from the Eocene of the Paris region exhibit a similar disposition. The shape of the columella, the terminal bulging zone of accretions, as well as the decoration of the shell, all agree with *Melongena*. The tall spire readily distinguishes this species from others of the same size and character. The elongate, feebly bent columella and the single spinose keel locate it in the sub-genus *Pugilina*.

As a considerable portion of the wall of the body-whorl is missing, fig. 1, Pl. II (*loc. cit. in syn.*) meant to represent the front of the shell approximately coincides with the back, and fig. 2 with the front. In fig. 3, Pl. V, an attempt has been made to illustrate the approximate restored outline.

Occurrence.—Upper Ranikot, zone 4: Jhirak (Vredenburg K $\frac{7}{189}$); left bank of Indus opposite Jhirak (Vredenburg K $\frac{7}{309}$).

MELONGENA (PUGILINA) PRÆPARADISIACA n. sp.

Pl. I, fig. 5.

This shell closely resembles the living *Melongena paradisiaca* Martini of the Indian Ocean from which it is distinguished by its

[1] See *Rec. Geol. Surv. Ind.*, Vol. LIII, p. 327.

more elevated spire, the apical angle of which ranges from less than 60° to 75°, while it is over 90° in the recent shell.

Occurrence.—Sit Chaung : Ngahlaindwin clays.

MELONGENA (PUGILINA) ICKEI Martin.

1906. *Melongena Ickei* Martin.—*Samml. des geol. R.-Mus. in Leiden,* new ser., I, p. 309, Pl. XLV, fig. 731.

As in the case of both the Javanese specimens, the solitary specimen from Burma lacks the anterior extremity of the shell. It reaches larger dimensions than the Javanese type, its breadth measuring no less than 80 mm. The spines on the last part of the body-whorl are even more elongated than on the type, though, at equal dimensions, the Burmese specimen and the Javanese type exactly agree.

Occurrence.—Mindegyi.

Genus : SEMIFUSUS Swainson 1840.

The following species is the only representative of the genus at present known from the Tertiary formations of India :—

SEMIFUSUS HERONI n. sp.

Pl. III, fig. 4.

This species is very closely related to *Semifusus timorensis* Martin from the Miocene of Timor and Java (*Samml. des geol. R.-Mus. in Lied.*, Vol. III, p. 101, Pl. VI, fig. 101 ; new ser., Vol. I, p. 95, Pl. XV, fig. 214), in which the greatest width corresponds with the angulation of the whorls instead of being situated quite close to the anterior suture ; principally in consequence of this disposition, the body-whorl and the aperture are shorter than in the Burmese fossil. Amongst living species, *Semifusus pastinaca* [Reeve] from the coasts of Australia and *S. lactens* [Reeve] from the Philippines bear a very close resemblance to the Burmese fossil, from which they are distinguished by their more numerous, and, at the same time broader ribs.

Occurrence.—Thetkegyin.

Family :- CHRYSODOMIDÆ.

Genus : SIPHONALIA A. Adams 1863.

The following species of *Siphonalia* are known from the Tertiary formations of India :—

1. *Siphonalia Cotteri* n. sp.
2. ,, (*Kelletia*) *nodulosa* [J. deC. Sow.] Gáj of Kachh.
3. ,, (*Kelletia*) *mekranica* Vred. Mekran beds.
4. ,, (*Kelletia*) *kelletiiformis* n. sp.
5. ,, (*Kelletia*) *iravadica* Vred.
6. ,, (*Kelletia*) *subspadica* Vred. (*Rec. Geol. Surv. Ind.*, Vol. LI, p. 310, Pl. IX, fig. 6) Dalu, Garo Hills.
7. ,, (*Pisanion*) *heptozodes* Cossmann. (*Journ. Conch.*, 1903, Vol. L, p. 133, Pl. IV, fig. 23). Pliocene of Karikal.

SIPHONALIA COTTERI n. sp.

Pl. III, fig. 5.

This shell appears to belong to the same group as *Siphonalia cassidariæformis* Reeve, though not closely related enough to any described recent species to necessitate detailed comparisons. It resembles *Streptochetus crassicostatus* [Desh.] from the Eocene of the Paris region, but is readily distinguished by its wider spire and the increased spacing of the nodes with increasing growth.

Occurrence.—Payagyigon.

SIPHONALIA (KELLETIA) KELLETII FORMIS n. sp.

Pl. II, fig. 11.

This shell shows the closest resemblance in shape to certain forms of *Siphonalia Kelletii* Forbes, the genotype of *Kelletia* Bayle. Nevertheless it is smaller and lacks the distinct umbilicus of *Siphonalia Kelletii.* Another shell which exhibits the closest resemblance to the Burmese fossil is *Fusus crassicostatus* Desh. from the Eocene of the Paris region which Cossmann regards as *Streptochetus* while pointing out its extraordinary resemblance to *Kelletia.* In *Fusus crassicostatus* the ribs are more persistent on the body-whorl than in the Burmese shell. *Siphonalia heptozodes* Cossmann from the Pliocene of Karikal is smaller, its base is relatively wider and more

rapidly contracted anteriorly, its spiral ornamentation somewhat more crowded and somewhat more prominent, while it shows no indication of the columellar fold visible on specimens of equal dimensions of the Burmese shell.

Occurrence.—Myaukmigon, Thanga.

SIPHONALIA (KELLETIA) IRAVADICA Vred.

Pl. I, fig. 8.

1895. *Fasciolaria nodulosa* Sow. *sec.* Noetling (*pars*).—*Mem. Geol. Surv. Ind* Vol. XXVII, Pl. VIII, fig. 3 (*non* fig. 1, 2 -*Lathyrus indicus*).

1901. *Fasciolaria nodulosa* J. de C. Sowerby *sec.* Nœtling (*pars*). *Pal Ind.*, new ser., Vol. I, part 3, p. 314, Pl. XX, fig. 17 (*non* Pl. XX, fig. 16, *nec* Pl. XXI, fig. 1 *Lathyrus indicus*).

1921. *Siphonalia (Kelletia) iravadica* Vred. *Rec. Geol. Surv. Ind.*, Vol. LI, pp. 272, 273, 287.

This species has already been discussed in these Records (*loc. cit. in syn.*). It is perhaps an ancestral premutation of *S. Kelletii-formis*. It is here illustrated to supplement the indifferent figures in Nœtling's monographs.

Occurrence.—Minbu, "zone of *Cancellaria martiniana*"; Mindegyi.

Genus: CYRTOCHETUS COSSMANN 1889.

The following species is the only one at present known from the Tertiary of India. :—

CYRTOCHETUS (LOSCOTAPHRUS) MINBUENSIS (Nœtling].

1895. *Cassidaria minbuensis* Nœtling. *Mem. Geol. Surv. Ind.*, Vol. XXVII, part 1, p. 28, Pl. VI, fig. 4.

1901. *Oniscidia minbuensis* Nœtling. *Pal. Ind.*, new ser. Vol. 1, p. 296, Pl. XIX, figs. 18, 19.

1921. *Cyrtochetus (Loscotaphrus) minbuensis* [Nœtl.] Vredenburg, *Rec. Geol. Surv. Ind.*, Vol. LI, pp. 269, 288.

This interesting shell so closely resembles *Phos varicifer* Tate, from the Tertiary of Australia, the genotype and hitherto only known representative of *Loscotaphrus* Harris, as to give rise to considerable hesitation as to whether it should not be regarded as a mere variety of the Australian form, from which it is distinguished by its somewhat more ventricose outline, the much more callous aperture. and the absence of differentiated intercalary spiral threads of a second order.

Occurrence.—Minbu, "zone of *Cancellaria martiniana*"; Payagyigon.

Family: STREPTURIDÆ.

Genus: STREPSIDURA Swainson 1840.

The following species are known from the Eocene of India:—

1. *Strepsidura indica* Cossmann and Pissarro (*Pal. Ind.*, new ser., Vol. III, Mem. 1, p. 33, Pl. III, figs. 33, 34). Ranikot of Sind, zones 2 to 4. Yeshin, in the Laungshe shales.
2. „ *Cossmanni* n. sp.

STREPSIDURA COSSMANNI n. sp.

Pl. II, fig. 5.

Compared with *Strepsidura indica* C. and P., this shell has a somewhat shorter spire, a more pronounced posterior concavity of the whorls, a decidedly more elongate body-whorl, a more elongate, less twisted anterior stem, a less prominent terminal zone of accretions, more crowded axial ribs, and a generally coarser ornamentation.

Occurrence.—Upper Ranikot. Zone 1: broken ground among the hills under Jakhmari peak (Nœtling K $\frac{7}{650}$); two miles east of Kandaira, Vera plain east (Fedden G $\frac{280}{181}$).

Family: BUCCINIDÆ.

Genus: COMINELLA Gray 1857.

The following is the only species at present known from the Tertiary of India:—

Cominella Annandalei Vred. Nari of Sind.

Genus: CYLLENE Gray 1833.

The following species of *Cyllene* are known from the Tertiary formations of India:—

1. *Cyllene pretiosa* n. sp.[1]
2. „ *varians* Cossmann (*Journ. Conch.*, 1903, Vol. L, p. 134, Pl. VI, fig. 18-20). Pliocene of Karikal.

[1] Another undescribed species of *Cyllene* occurs at Tittabwe, but the solitary fragile type has collapsed and cannot be figured. It closely resembles *C. varians* Cossm. from the Pliocene of Karikal from which it is distinguished by its unusually tall slender spire. Compared with living forms it somewhat unites the ornamentation of *C. lyrata* Lam. with the more elongate shape of the almost smooth *C. pulchella* Ad. and Reeve, or *C. concinna* Sol.

CYLLENE PRETIOSA n. sp.

Pl. II, fig. 2.

This shell appears to be closely related to *C. orientalis* A. Ad. and to *C. senegalensis* Petit, regarded by Tryon as probably varieties of *C. Oweni* Petit. So far as can be made out from figures and descriptions, it is distinguished by the dimorphism of its spire and by the peculiar bulbous disposition of the apex.

Occurrence.—Dalabe, Thanga, Tittabwe.

Genus : LACINIA Conrad 1853.

The following species of *Lacinia* are known from the Tertiary formations of India :—

1. *Lacinia indica* Vred. (*Rec. Geol. Surv. Ind.*, Vol. LIII, p. 341, Pl. XXII, fig. 3). Kyudaw Chaung east of Pasok.
2. ,, *minbuensis*. Vred. (*Rec. Geol. Surv. Ind.*, Vol. LIII, p. 341, Pl. XXII, figs. 4, 5). Minbu "zone of *Cancellaria martiniana*;" Singu "C-D".

Genus : PHOS Montfort 1810.

The following species of *Phos* are known from the Tertiary formations of India :—

1. *Phos acuminatus* Martin.
2. ,, *macrostoma* Cossmann (*Journ. Conch*, 1903, Vol. L, p. 146, Pl. V, fig. 3). Tertiary of Karikal.

PHOS ACUMINATUS Martin.

1878. *Buccinum (Phos) acuminatum* Martin.—Tertiarsch. auf Java, p. 37, Pl. VII, fig. 5.

1906. *Phos acuminatus* Mart.—*Samml. des geol. R.-Mus. in Leiden*, new ser., Vol. I, p. 311, Pl. XLV, fig. 732.

This species is represented by a large number of specimens, all of small size, corresponding in their dimensions with the one figured in Martin's latest monograph on the Tertiary of Java. The specimens exhibit a certain amount of variation in their proportions and in their ornamentation. The proportion of width to height varies from five-twelfths to more than one-half. The spacing of the axial ribs varies considerably: although sometimes very crowded

they are usually wider-spaced than in the specimens figured by Martin, sometimes much more so. The variations do not follow any uniform law: in certain specimens in which the ribs are very wide-spaced they become suddenly extremely crowded on the last part of the body-whorl. On account of the usually wider spacing of the ribs, the Burmese fossil may perhaps be distinguished as a variety *birmanica.*

Some of the species living in the eastern seas, such as *Phos senticosus* Linn. resemble this fossil but attain larger dimensions.

Occurrence.—Dalabe, Kyaungon, Sitsaba, Thanga, Tittabwe.

Genus: METULA H. and A. Adams 1853.

The following is the only species at present known from the Tertiary of India :—

Metula Martini Vred. Gáj of Sind.

Genus: TRITONIDEA Swainson 1840.

The following species of *Tritonidea* are known from the Tertiary beds of India :—

1. *Tritonidea praeundosa* n. sp.
2. ,, *promensis* n. sp.
3. ,, *Martiniana* [Noetl.]
3a. ,, *Martiniana* var. *arakanensis* n. var.
4. ,, *heptagona* n. sp.
5. ,, (*Cantharus*) *Bucklandi* [d'Arch.]
6. ,, (*Cantharus*) *erythrostoma* Reeve. Mekran beds.
7. ,, (*Cantharus*) *speciosa* n. sp.
8. ,, (*Cantharus*) *tranquebarica* [Martini] (= *Melongena octocostata* Cossmann, *Journ. Conch.*, Vol. L, p. 132, Pl. V, figs. 1, 2). Pliocene of Karikal.

TRITONIDEA PRÆUNDOSA n. sp.

Pl. II, fig. 1.

The resemblance between this shell and *Buccinum undosum* Linn., the genotype of *Tritonidea,* is so close as to give occasion to some hesitation as to whether it should be regarded as specifically distinct. The main difference is the much smaller size of the fossil which measures less than half the height of the living species. Even on the supposition that the solitary available specimen is immature,

the proportions of the spire-whorls still indicate a much smaller form. Minor differences are the presence of well-developed though very delicate intercalary striations between the main spiral threads of the fossil, and the absence of the broad, faint, axial swellings which sometimes decorate the living form. Though these differences may provisionally be regarded as specific, there is reason to believe that the fossil represents an ancestral premutation of the common recent shell of the eastern seas.

Occurrence.—Dalabe.

TRITONIDEA PROMENSIS n. sp.

Pl. II, fig. 8.

The conical outline of the whorls, their double angulation, and the deeply impressed sutures readily distinguish this beautiful species from its congeners. In general outline it resembles *T. gemmata* Reeve and *T. undosa* Linn. of the Pacific and Indian regions. Amongst fossil species, *T. Everwijni* Martin from the Miocene beds of Java is closely related.

Occurrence.—Dalabe, Tittabwe.

TRITONIDEA MARTINIANA [Noetl.]

1895. *Nassa cantleyi* d'Archiac *sec.* Noetling.—*Mem. Geol. Surv. Ind.*, Vol XXVII, p. 32, Pl. VII, figs. 2-4.
1901. *Cancellaria martiniana* Noetling.—*Pal. Ind.*, new ser., Vol. I, part 3, p 332, Pl. XXII, figs. 11-13.
1908. *Cantharus Martinianus* [Noetling].—Dalton, *Q. J. G. S.*, Vol. LXIV, p. 630, Pl. LV, figs. 6, 7.
1921. *Tritonidea Martiniana* [Noetl.]—Vredenburg, *Rec. Geol. Surv. Ind.*, Vol LI, pp. 276, 288.

The subdued decoration recalling certain species of *Pisania* distinguishes *T. Martiniana* from the numerous species both fossil and recent which have approximately the same shape. The wrinkled columella shows that the species is a typical *Tritonidea*, not a *Pisania.*

Occurrence.—Minbu ; Mindegyi ; Singu, "A," "L," "P."[1] ; also, according to Noetling, Yenangyat, "zone of *Paracyathus caeruleus.*"

TRITONIDEA MARTINIANA [Noetl.] var. ARAKANENSIS n. var.

This variety is distinguished from the type by the much more numerous ribs on its later spire-whorls and especially on the body-

[1] See *Rec. Geol. Surv. Ind.*, Vol. LIII, pp. 326, 327.

whorl where their number is not less than 35 and may reach 45, while in the type it oscillates between 12 and 21. The spiral threads are slightly more prominent than on the type, but just as numerous and distributed in exactly the same manner.

Occurrence.—Ngahlaindwin; Payagyigon.

TRITONIDEA HEPTAGONA n. sp.

Pl. II, fig. 4.

This is one of the few fossils from Burma that closely resembles certain European Miocene forms and at the same time bears no analogy to any living eastern species. Several Miocene forms from Europe such as *T. ponderosa* Bellardi, *T. compressa* Bellardi, *T. rhomba* Dujardin, have exactly the same ornamentation and the same apertural details, but their proportions are not so slender.

Occurrence.—Thànga.

TRITONIDEA (CANTHARUS) BUCKLANDI [d'Archiac.]

Pl. II, figs. 9, 10.

1850. *Fusus Bucklandi* d'Arch.—Hist. des progr. de la Géol., Vol. III, p. 292.

1854. *Fusus ? Bucklandi* d'Arch.—D'Archiac and Haime, Descr. an. foss. gr. numm Inde, p. 308, Pl. XXIX, fig. 13.

? 1884. *Pollia luliana* Martin.—*Samml. des geol. R.-Mus. in Leid.*, ser. 1, Vol. III, p. 105, Pl. VI, fig. 106.

Illustrations of this important species are here published to supplement d'Archiac and Haime's figure of the incomplete type from Sind. In some specimens (fig. 10), the principal threads alternate in two sizes and have a crowded appearance. In other specimens (fig. 9), only the principal threads of the larger size are developed, the intervals being occupied by close-set thin raised lines.

Occurrence.—Dalabe, Thanga, Tittabwe, also in the Gáj of Sind.

TRITONIDEA (CANTHARUS) SPECIOSA n. sp.

Pl. II, fig. 6.

? 1883. *Buccinum (Pollia) ventriosum* Martin.—*Samml. d. geol. R.-Mus. in Leid.*, Vol. I, p. 204, Pl. IX, fig. 7.

? 1895. *Tritonidea ventriosa* Martin.—*Samml. d. geol. R.-Mus. in Leid.*, new ser., Vol. I, p. 99.

The form nearest related to this beautiful shell is *Tritonidea ventriosa* Martin from the Miocene of Java with which the discovery

of further material may eventually perhaps enable the Burmese shell to be united as a variety. For the present the Burmese fossil is distinguished by the following differences: it has only seven ribs to each whorl instead of the nine or ten of the Javanese form; the ribs of the Burmese fossil are much more antecurrent towards the posterior suture; the spiral ornamentation of the body-whorl, in the Burmese fossil, is more profuse, more even and more delicate; the Javanese fossil shows a greater tendency towards the development of an umbilicus.

Occurrence.—Tittabwe.

Genus : LEVIBUCCINUM Conrad 1865.

The following is the only species at present known from the Tertiary of India :—

Levibuccinum (*Euryochetus*) *nassaforme* Cossmann and Pissarro (*Pal. Ind.*, new ser., Vol. III, Mem. 1, p. 34, Pl. III, figs. 21, 22). Lower Eocene of Sind.

Genus : EBURNA Lamarck 1822.

The following species of *Eburna* are known from the Tertiary of India :—

1. *Eburna spirata* Lamarck. Mekran beds and Pliocene of Karikal.
2. „ *lutosa* Lamarck (*Rec. Geol. Surv. Ind.*, Vol. LI, pp. 271, 288). Kama, Prome, Sitsaba.
3. „ *occlusa* Cossmann (*Journ. Conch.*, Vol. L, p. 137, Pl. V, fig. 25). Pliocene of Karikal.

Family : NASSIDÆ.

Genus : NASSA Lamarck 1799.

The following species of *Nassa* are known from the Tertiary of India :—

1. *Nassa ovum* Cossmann (*Journ. Conch.*, Vol. L, p. 138, Pl. IV, fig. 25). Pliocene of Karikal.
2. „ (*Niotha*) *gemmulata* Lamarck (Cossmann, *Journ. Conch.*, Vol. L, p. 143, Pl. V, fig. 11). Pliocene of Karikal.

3. *Nassa* (*Hinia*) *karikalensis* Cossmann (*Journ. Conch.*, Vol. L, p. 139, Pl. V, figs. 16, 17). Pliocene of Karikal.
4. ,, (*Hinia*) *colpophora* Cossmann (*Journ. Conch.*, Vol. L, p. 140, Pl. V, figs. 6, 7). Pliocene of Karikal.
5. ,, (*Telasco*) *Verbeeki* Martin (Cossmann *Journ. Conch.*, Vol. L, p. 142, Pl. V, figs. 8, 9). Pliocene of Karikal.
6. ,, (*Telasco*) *Falconeri* [d'A. and H.]. Gáj of Sind.
7. ,, (*Telasco*) *mekranica* Vred. Mekran beds.
8. ,, (*Zeuxis* ?) *Cautleyi* [d'A. and H.]. Gáj of Sind.
9. ,, (*Zeuxis* ?) *Fittoni* [d'A. and H.]. Gáj of Sind.
10. ,, (*Hebra*) *Bouneti* Cossmann (*Journ. Conch.*, Vol. L, p. 144, Pl. V, figs. 4, 5). Pliocene of Karikal.

10*a*. ,, (*Hebra*) *Bouneti* var. *kachhensis* Vred. Gáj of Kachh.

11. ,, (*Hima*) *Vicaryi* [d'Arch.]. Gáj of Sind.
12. ,, (*Amycla*) *dimorpha* Cossmann (*Journ. Conch.*, Vol. L, p. 145, Pl. V, figs. 12,13). Pliocene of Karikal.

The absence, from the Burmese Tertiary, of the genus *Nassa* abundantly represented in the later Tertiary formations of Java, Karikal, and Western India, is in keeping with the deeper-sea facies of the Miocene of Burma.

Family: COLUMBELLIDÆ.

The following species described by Cossmann from the Pliocene of Karikal are the only *Columbellidæ* at present known from the Tertiary of India :—

Genus: ANACHIS H. and A. Adams 1853.

Anachis crassicostata Cossmann (*Journ. Conch.*, Vol. L, p. 147, Pl. V, figs. 14, 15). Pliocene of Karikal.

Genus: ATILIA H. and A. Adams 1853.

Atilia simplex [Martin] (Cossmann, *Journ. Conch.*, Vol. L, p. 149, Pl. V, figs. 18, 19). Pliocene of Karikal.

APPENDIX.

Amongst the numerous Pleurotomidæ of the Miocene of Burma is a remarkable form apparently exhibiting the characters of the genus *Bela.* As this genus is completely unknown from the faunas either recent or fossil of the eastern seas, I thought it advisable to postpone its description until its generic characters could be re-examined. It was therefore omitted from No. 2 of the present series dealing with the Pleurotomidæ (*Rec. Geol. Surv. Ind.*, Vol. LIII, p. 83). As however, on further examination, I cannot find that it fits into any other genus, it is here figured together with a comparative diagnosis.

Genus : BELA (Leach) Gray 1847.

The following is the only form of the genus at present known in India :—

BELA (HÆDROPLEURA) ORIENTALIS n. sp.

Pl. II, fig. 12.

? 1846. *Mangelia plicalabrum* Reeve.—*Proc. Zool. Soc.*, p. 63, and Monograph of the genus *Mangelia*, Pl. VI, sp. 43.

? 1884. *Mangilia* (*Cythara*) *plicalabroides* Tryon.—*Man. Conch.*, Vol. VI, p. 263. Pl. XXI, fig. 28.

After a careful consideration of all the characters of this shell, it does not seem possible to classify it elsewhere than in the *Hædropleura* section of the genus *Bela.* It closely resembles certain species of the genus *Mangilia* and of its sub-genus *Eucithara.* Nevertheless, the complete absence of any trace of an apertural sinus excludes its reference to *Mangilia s. str.*, while a reference to *Eucithara* is equally impracticable in consequence of the internally smooth outer lip. It seems therefore necessary to admit that the essentially Mediterranean form *Hædropleura* existed in the Miocene seas of the East.

Compared with the genotype of *Hædropleura*, *Bela septangularis* Montagu, living in the Mediterranean, fossil in the Miocene and Pliocene of Europe, the Burmese shell is distinguished by its rather narrower, thinner, sharper ribs, and the almost complete absence of waviness of the sutures. It is very doubtfully distinct from the living *Mangilia*

planilabroides Tryon (=*Mangilia planilabrum* Reeve) from the Philippines, the very name of which suggests the possibility of its being a *Bela* rather than a *Mangilia*, but the inadequacy of the available figures and descriptions precludes all attempt at a precise identification.

Occurrence.—Dalabe, Thanga.

ILLUSTRATIONS.

PLATE I.

FIG. 1.—EUTHRIOFUSUS ALOMPRÆ n. sp. Payagyigon, Enlarged 3·2.
FIG. 2.—LATHYRUS IRAVADICUS n. sp., Dalabe. Enlarged 2·1.
FIG. 3.—LATHYRUS INDICUS n. sp., Payagyigon. Natural size.
FIG. 4.—LATHYRUS (PERISTERNIA) PROMENSIS n. sp., Myaukmigon. Enlarged 2·1.
FIG. 5.—MELONGENA PRÆPARADISIACA n. sp., Sit Chaung, Ngahlaindwin Clay. Natural size.
FIG. 6.—LATHYRUS PSEUDOLYNCHOIDES n. sp., Thanga. Enlarged 3·2.
FIG. 7.—LATHYRUS PSEUDOLYNCHOIDES n. sp., Myaukmigon. Enlarged 3·2.
FIG. 8.—SIPHONALIA (KELLETIA) IRAVADICA n. sp., Mindegyi. Enlarged 3·2.
FIG. 9.—CLAVILITHES ARAKANENSIS n. sp., Ngahlaindwin. Enlarged 3·2.

PLATE II.

FIG. 1.—TRITONIDEA PRÆUNDOSA n. sp., Dalabe. Enlarged 5·2.
FIG. 2.—CYLLENE PRETIOSA n. sp., Dalabe. Enlarged 3·1.
FIG. 3.—FUSUS PROMENSIS n. sp., Thanga. Enlarged 2·1.
FIG. 4.—TRITONIDEA HEPTAGONA n. sp., Thanga. Enlarged 4·1.
FIG. 5.—STREPSIDURA COSSMANNI n. sp., Jakhmari. Enlarged 2·1.
FIG. 6.—TRITONIDEA (CANTHARUS) SPECIOSA n. sp., Tittabwe. Natural size.
FIG. 7.—FUSUS BUDDHAICUS n. sp., Tetma. Enlarged 3·2.
FIG. 8.—TRITONIDEA PROMENSIS n. sp., Tittabwe. Enlarged 3·1.
FIG. 9.—TRITONIDEA (CANTHARUS) BUCKLANDI d'A. and H. Dalabe. Enlarged 3·2.
FIG. 10.—TRITONIDEA (CANTHARUS) BUCKLANDI d'A. and H. Thanga. Enlarged 3·2.
FIG. 11.—SIPHONALIA (KELLETIA) KELLETIIFORMIS n. sp., Thanga. Enlarged 3·2.
FIG. 12.—BELA (HÆDROPLEURA) ORIENTALIS n. sp., Thanga. Enlarged 2·1.

PLATE III.

FIGS. 1, 2.—CLAVILITHES COSSMANNI n. sp., Kyudaw Chaung. Natural size.
FIG. 3.—FUSUS HUMEI n. sp., Payagyigon. Natural size.
FIG. 4.—SEMIFUSUS HERONI n. sp., Thetkegyin. Enlarged 3·2.
FIG. 5.—SIPHONALIA COTTERI n. sp., Payagyigon. Enlarged 3·2.

PLATE IV.

MELONGENA PRÆMELONGENA n. sp., Shinmadaung. Natural size.

PLATE V.

FIG. 1.—CLAVILITHES LEILANENSIS n. sp., Near Leilan, Restored outline. Natural size.

FIG. 2.—CLAVILITHES COSSMANNI n. sp., Kyudaw Chaung Restored outline. Natural size.

FIG. 3.—MELONGENA (PUGILINA) MURICIFORMIS C. and P. Jhirak, zone 4. Restored outline. Natural size.

ON THE GEOLOGICAL INTERPRETATION OF SOME RECENT GEODETIC INVESTIGATIONS (BEING A SECOND APPENDIX TO THE MEMOIR ON THE STRUCTURE OF THE HIMALAYAS AND OF THE GANGETIC PLAIN AS ELUCIDATED BY GEODETIC OBSERVATIONS IN INDIA). BY R. D. OLDHAM, F.R.S.

SINCE the appearance of the Memoir on the Structure of the Himalayas, and of the Gangetic Plain, as elucidated by Geodetic Observations in India[1] and the Appendix on the Support of the Mountains of Central Asia[2], other contributions to our knowledge of the subject have been published, of which three appear to require special consideration. Two of these have been issued by the Survey of India, and contain the results of a large amount of computation, having important bearings on the problem of the origin of the Himalayas and, incidentally, on the wider one of the origin of mountains in general.[3] The third is an important study of the question of compensation and isostasy by Prof. A. Alessio, which contains also the results of the observations of gravity and deflection of the plumb line, made in the course of the Filippi expedition to Central Asia.[4]

Had Col. Cowie's 'criticism' been no more than its title indicates, no useful purpose would be served by a merely controversial rejoinder, but, in addition, it contains some important results of computation. The criticisms are numerous and detailed, in some cases they deal with mere slips of the pen or printer, in others they point out real mistakes, and in others again it is Col. Cowie who is in error. So far as they refer to matters of detail, I do not propose to deal with

[1] *Mem. Geol. Surv. Ind.*, Vol. XLII, pt. 2, (1917).

[2] *Rec. Geol. Surv. Ind.*, Vol. XLIX, pp. 117-135, (1918).

[3] Colonel Sir S. G. Burrard, "Investigation of Isostasy in Himalayan and neighbouring Regions," *Surv. Ind. Prof. Paper*, No. 17, (1918).

Lieut.-Col. H. McC. Cowie, "A criticism of Mr. R. D. Oldham's Memoir. The Structure of the Himalayas, and of the Gangetic Plain as elucidated by Geodetic observations in India." *Sur. Ind. Prof. Paper*, No. 18, 1921.

[4] Prof. Alberto Alessio. "Dubbie Idee sull'isostasi terrestre". *Rivista Marittima*, March 1922, supplement.

them ; [1] but a few matters of principle may well be noticed, before passing on to the consideration of the fresh information contained in his paper.

At the outset he states that " Mr. Oldham .....appears..... to be of the opinion that we need look no further than the Gangetic Trough, filled with alluvium, for the explanation of the anomalies of the plumb-line deflection and intensity of gravity. " Further on he adds, " the aim of the Memoir is, perhaps, the evolution out of the material afforded by geodetic determinations, of the shape of the trough rather than the solving of the problem presented by the gravitational anomalies.''[2] The " perhaps " of the latter of these two quotations was quite explicitly and avowedly one of the main purposes of the Memoir, and the passage first quoted is the more remarkable as I had endeavoured to show that neither the deflections and anomalies, nor the residuals left after allowing for compensation, could be wholly accounted for by the lessser density of the Gangetic alluvium, and that some other, additional, cause must be invoked. This conclusion may not have been sufficiently clearly developed in the text but it is quite clearly and definitely claimed in the summary at the end of the memoir.[3] The matter had to be considered because this explanation had been suggested by an authority, [4] whose other ideas have been widely accepted and had never been tested, for confirmation or the reverse.

The next point to be considered is the criticism of the use made of the Imaginary Range. Col. Cowie shows that the computed effect at certain stations differs from that derived from actual topography by amounts which are very material, from the geodetic point of view. This is true and natural, but the criticism does not touch the purpose or use made, of the concept, the argument throughout the Memoir being from the differences in effect at stations in the same region ;

[1] I may except the criticism, on pp. 8-9, of the statement in the Memoir that the observations of deflection at Gogipatri and Poshkar might be accepted as correct within one second of arc. The statement in the Memoir was made on the authority of the then Surveyor General, of whom I had enquired as to the reason for the exclusion of these observations from the final account, and the extent of the uncertainty of the deter-minations. In reply to this enquiry, I was courteously informed that the omission was due to the unfavourable weather conditions prevailing at the time, making the observa-tions of less precision than was demanded by the Trigonometrical Survey, and that the error was not likely in any case to exceed one second of arc. It is not a matter on which I should frame an independent opinion.

[2] *loc. cit.* p. 2.

[3] *loc. cit.* p. 136. See also figs. on pp. 115, 125 and explanatory text.

[4] Suess, " Das Antlitz der Erde," Vol. III, pt. 2, chap. 26.

to calculate these from the actual topography would be impossible for anyone unprovided with the resources of a properly organised computing office, and it seemed that an approximation, at any rate, to the order of magnitude of the differences, sufficiently close for the purpose of the investigation, could be obtained by assuming a simplified topography, which would simplify the calculations. For this purpose, the method seemed, and seems, justifiable, and no suggestion was made that it should be adopted for any other purpose, nor the results used in any other way.

Finally there is Col. Cowie's criticism and discussion of the centre of effect. He discusses in detail the question of whether, in a column of small cross section and considerable length, there could be any point at which the whole mass might be considered to be concentrated, so that the resultant attraction, at any given station, would be the same as that of the same mass distributed through the column. No such claim was, however, made in the Memoir; what was there asserted was that in any such vertical column there must be a point at which, if the mass were concentrated, the horizontal component of its attraction, or otherwise its effect on the plumb-line, would be the same as that of the same mass distributed through the column. That there must be some such point does not need elaborate demonstration, for if the whole mass were concentrated at the upper end of the column, the deflection produced would obviously be greater, and if concentrated at the lower extremity, less, than if distributed throughout the column; from this it follows that, somewhere between the two extremes, there must be a point where the effect would be the same, and this is equally true whether the density is, or is not, uniform throughout the column. Similarly there must be a point where, if concentrated, the attraction of the mass would have the same vertical component, or effect on the pendulum, as the same mass distributed through the length of the column. The question of whether these two centres of effect are, or are not, coincident was not considered, as it was not pertinent to the use made of them, but it is easy to see that, where the horizontal distance is small, compared with the vertical depth of the column, they must materially differ in position, from each other, from the centre of effect as dealt with by Col. Cowie, and from the centre of gravity of the column, and that, as the distance separating the column from the station increases, these four points will approach more closely to each other.

The principal object for which the concept was introduced was to examine into the effect which would follow on a change in the distribution of compensation. Near the edge of the hills there were large residuals of deflection and anomaly, one possible explanation was a difference in the distribution of compensation under the plains and the hills ; this had never been investigated or a numerical estimate formed, and it seemed that by treating the compensation in this simplified manner a useful idea could be formed of the order of magnitude and distribution of the corrections to the residuals, which would be reached in this manner. The method was applied and showed that neither in amount, nor distribution, was the modification such that more than a small fraction of the residuals could be so accounted for ; but the method was definitely put forward, as a purely preliminary trial to see whether a more detailed examination of the question was needed ; for this purpose, and within these limits, it seems justifiable, nor is there any novelty in it. In principle it is identical with Helmert's method of condensation, though in his case the treatment was necessarily less simple, as greater precision of result was aimed at, than was needed for the purpose of the Memoir.

It will be seen, then, that the criticisms are largely based on misconception, yet this is not to be regretted as it has led to important additions to our knowledge, and we have now detailed calculations at a number of stations which were not available when the Memoir was being written. The result of these calculations is that the approximate methods there used, which were justifiable and necessary in 1914, are no longer needed ; the effect of topography, compensation, and of the alluvium has now been computed in detail at a sufficient number of stations to allow of the results being used directly, in testing those of the conclusions, set forth in the Memoir, which bear on the origin of the Himalayas.

The calculations deal with the geodetic effect of an alluvium-filled trough, such as is indicated by geological evidence, and seems to be supported, or at least not contradicted, by geodetic observations. For the purpose of these computations Col. Cowie has prepared a map which purports to, and in the main does, show the form and dimensions of the trough, as deduced in the Memoir. The depths of alluvium are shown with greater precision than I should have been prepared to do, for throughout the Memoir it is distinctly stated that the figures given can only be taken as good indication of the

relative depths in different portions of the trough, representing no more than the order of magnitude of the absolute depths; this precision of statement is, however, essential to numerical calculation, and the general form is in accordance with the conclusions of the Memoir, except that the ridge separating the two deeps is placed a little further east than I should put it. The northern boundary does not follow exactly that shown in the map attached to the Memoir, as it follows neither the boundary of the alluvium, nor that of the Siwalik rocks; from the Dehra Dun eastwards it follows the former, to the westwards it trespasses on the Siwalik area and includes a portion, but not the whole, of that strip of lighter rock fringing the area occupied by the older and denser rocks of the Himalayas. On the south the boundary agrees with mine at both ends, but in the middle departs considerably from it. The southern boundary of the deep alluvium is shown in the Memoir a little northwards of Delhi, thence curving on both sides to meet the general course of the boundary; Col. Cowie obliterates this imbayment and carries the boundary in an even sweep across the Aravalli hills, placing it, at one place, some 60 miles from the position shown on the Memoir map, and indicating a depth of over 5,000 feet of alluvium where the geological map clearly shows that rock is exposed at the surface. This error, unfortunately, comes in just where the series of stations treated is most complete; the result is that at three of them, Noh, Agra and Usira, the computed effect is greater than that which would result from the conditions indicated in the Memoir, but the absolute effect of the divergence is small as the southerly deflections at these stations computed by Col. Cowie, amount to only 1″, 2″, 1″, respectively. At other stations the effect of the difference in the boundary adopted is even smaller, and negligible in comparison with the uncertainty in the vertical dimensions made use of; yet in a work which takes objection to approximate methods, it would have been well to obtain a degree of precision in the fundamental data of computation, which could have been secured by anyone familiar with the interpretation of geological maps.

Besides the effect of the alluvium, there is that of the lesser density of the Siwalik rocks, which has not been considered by Col. Cowie, though it would be quite appreciable at three of his stations, Mussoorie, Dehra Dun and Birond. At Mussoorie the effect has been computed by Sir S. G. Burrard[1] as—3″; at Dehra Dun he gives no separate estimate, but with the dimensions of the tract and the

[1] *loc. cit.*, p. 35.

position of the station it would not be materially different from the same value; at Birond the width of the Siwalik tract is about half that of the Dehra Dun region, but as the station is nearer to the boundary, the net effect may be taken as somewhat less than at Mussoorie or say—2″. All these values depend on the supposition that the surface of separation between the Siwalks and the older rocks slopes steeply, at an angle of over 45° from the horizontal: if the dip of the contact is much less than that the effect at Mussoorie and Birond would be greater. and at Dehra Dun less, than these figures, but the change would not be more than a fractional part of them.

Even with these additions Col. Cowie's figures prove conclusively that the peculiarities of the residuals of attraction in the neighbourhood of the margin of the mountains can only partially be attributed to the effect of the lesser density of the Gangetic alluvium. This may be seen from the figures reproduced in the table No. I,

TABLE I.

Deflections, and Residuals of deflection, at stations over and near the Gangetic Alluvium, as deduced by consideration of an alluvial trough in addition to surface masses, by Col. H. McC. Cowie.

Station.	Observed deflection.	Calculated effect of trough alone.		Calculated deflections supposing.		Residuals	
		Uncompensated	Compensated	No trough	A trough.	Cols. 2—5	Cols. 2—6.*
1	2	3	4	5	6	7	8
	″	″	″	″	″	″	″
Lambatach .	—27	—5	—1	—9	—11	—18	—16
Mussoorie . .	—30	—7	—2	—17	—20	—13	—10(—7)
Dehra Dun . .	—31	—6	—2	—18	—20	—13	—11(—8)
Kaliana . .	—1	0	+1	—3	—2	+2	+1
Bangeopal . .	+1	+1	+1	—1	—1	+2	+2
Noh . . .	+5	+4	+1	—1	+1	+6	+4(+5)
Agra . . .	0	+5	+2	0	+2	0	—2 (0)
Usira . . .	—1	+4	+1	0	+2	—1	—3(—1)
Kesri . . .	+10	+2	0	+1	+1	+9	+9
Pahurgarh . .	+4	+2	0	+1	+1	+3	+3
Birond. . .	—38	—12	—5	—14	—21	—24	—17(—15)
Pathardi . .	—14	—12	—6	—3	—10	—11	—4
Nimkar . .	+5	+4	+2	—1	+1	+6	+4
Sora . . .	+11	+10	+4	0	+4	+11	+7
Kanakhera . .	+10	+8	+2	0	+3	+10	+7
Siliguri . .	—18	—3	—1	—11	—13	—7	—5
Jalpaiguri . .	—1	—2	—1	—8	—9	+7	+8
Chandurla . .	+9	+3	+1	—2	—1	+11	+10

* Figures in brackets represent residuals after allowing for the effect of the Siwalik tract, and of difference between Col. Cowie's trough and that of the Memoir, as referred to in the text.

where three groups, forming three cross sections, are arranged each in order of increasing distance from the main axis of the Himalayas. For each station there is given, the observed deflection, the computed effects of the visible topography and of the assumed alluvial trough and the residuals before and after allowing for the decrease in density of the alluvium of the Gangetic plains ; in the last column I have added, for the three stations referred to above, the residual as it would be if the effect of the Siwalik tract were also considered ; and at three others, Noh, Agra, and Usira, the probable values, if the southern contours of the trough had been in accordance with the form indicated in the Memoir and by geological survey.

The figures show that, after allowing for the effect of the alluvium there are still large northerly residuals in the outer hills to the north of the alluvium, and large southerly residuals in the rock area to the south. The former of these disappear rapidly near the edge of the hills and give place to southerly deflections : it was to account for this that Sir S. G. Burrard suggested the existence of a 'rift' or belt of material of less density than the average of the material on either side. So long as deflections only are considered it is a feasible explanation, and it would be possible to work out numerically the dimensions and deficiency of density, which would be necessary to fit in with observation, but it is not consistent with the co-existence of large residuals of positive anomaly and northerly deflection in the outer Himalayas. The latter is an important objection, it does not make the existence of the 'rift' impossible, but it shows that this can at best be only a partial explanation, and that there must be some other cause of the peculiarities shown by the residuals of anomaly and deflection.

One such cause was suggested in the Memoir[1] and may be briefly reconsidered. The principal is represented diagrammatically in the Fig. 1. where the dotted line may be taken to represent what would be the

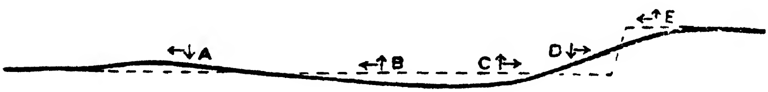

FIG I.

[1] *loc. cit.*, p. 115, fig. 8 ; p. 127, fig. 10.

surface if, the portion to the right having been uplifted, the principle of isostasy had been completely effective at every point, and compensation completely in accord with the surface inequalities of elevation and depression; and, assuming a certain degree of rigidity in the outer crust, combined with some capacity of yielding in the underlying material the firm line might represent the real surface contour, so that at A the surface stands too high, at B and C too low, and at D too high, to correspond with that underground variation in density, which would give an ideally perfect compensation. The effect of this divergence between the actual surface and the surface of equilibrium, on the pendulum and plumb line is indicated by the arrows; at A, corresponding to the hills south of the alluvium, there would be positive anomalies accompanied by southerly residuals of deflection, at B negative anomalies and southerly residuals of deflection, at C the anomaly is still negative but the residual of deflection northerly, and at D the northerly residual of deflection is accompanied by a positive anomaly. At E the actual would lie below the ideal surface and negative anomalies would be combined with southerly residuals of deflection. The evidence of this combination is not complete in the Himalayas, but its presence is suggested by recent observations, and apart from this the sequence deduced from the hypothesis agrees with that which is actually observed, and consistently exhibited, by all the stations, from the northern part of the Peninsula to the outer edge of the Himalayas. It would be possible to work out the amount, and variation, of departure from the level of equilibrium, which would most closely agree with observations, and doubtless to obtain a very close agreement, but no useful purpose would be served by such calculation for it would only be stating the same hypothesis in figures instead of words: at most it would give one possible solution of the problem, of which many others may be equally possible.

Some further evidence bearing on this question may be derived from Sir S. G. Burrard's investigation, which has been mentioned above. In this he takes the residuals at a number of stations, on the alluvium and in the rock areas to the north and south of it and then computes the depth of alluvium which should exist in the trough, if the whole of these residuals are attributed to the effect of the deficiency of mass in the alluvium, and the excess in its compensation. The

result is given in the form of the mean depth of alluvium which would produce the required effect, but the details of results at each station show that the method followed was to compute the deficiency of mass, in the form of the thickness of rock of average density, and to convert this into depth of alluvium, adopting a density of 2·4. The density of the alluvium not being relevant to the present purpose, which is only concerned with the defect of mass, it will be convenient to reconvert the figures given into the form of the equivalent deficiency in mass, expressed as thickness of rock of average density.

The results of the investigation are summarised in a series of tabular statements, each dealing with a separate cross section of the trough, the results obtained from pendulum and plumb-line observations being given in separate columns, and the stations classified in three groups according as they are situated over the trough, to the north, or to the south of it; an average is struck for each group and a general average of the whole is made.[1] The procedure is sound enough for some purposes, but, in making use of the results for elucidating, and extending, the conclusions to be drawn from geological observation, a somewhat different treatment will be more instructive. I have, therefore, rearranged the figures in a form which will enable an average to be struck for each of the three groups of stations, and for each of the two forms of geodetic measurement.

For this purpose I have used the original figures given in the detailed account of the various stations considered, instead of the summary, as the latter exhibits three discrepancies, one trivial but the other two material. In the central section, No. IV, there are two entries, one for stations north of, and the other for those over, the trough; reference to the details show that these figures refer to the stations Mussoorie and Dehra Dun, but the latter is not properly a station over the trough, being situated near the inner boundary of the Siwalik tract, and therefore to the north of the alluvial trough. At Mussoorie two separate estimates are given, firstly, after allowing for the effect of the deficiency in density of the rocks of the Siwalik tract, it is estimated that the deficiency over the trough itself amounts to the equivalent of 8,000 feet of average rock and, secondly, an estimate of the mean deficiency, taking the Siwalik tract as part of the trough, which works out at 2,500 feet. In the summary the latter is used, but the adoption does not seem justifiable, if the object is to measure the deficiency over the trough proper, which would account

[1] *loc. cit.*, pp. 15-17.

for the residual of deflection: for this reason I have adopted the former, in preference to the latter value. In the case of Dehra Dun only one estimate is given, in which the Siwalik tract is included with the alluvial trough; here also the proper course would be to consider the effect of the Siwalik tract separately, and then frame an estimate of the required deficiency over the alluvial trough. As this has not been done it is not possible to say more than that the resulting average deficiency over the trough would probably be rather less than at Mussoorie; the effect of the Siwalik tract would be about the same at the two stations, the residual to be accounted for would, consequently, be the same, but the station lying somewhat nearer to the trough, the deficiency required would be less. I have adopted 7,000 feet as an approximate figure, based on the estimate of 8,000 for Mussoorie.

Arranged in this manner the stations, at which estimates could be framed, are shown in the tabular statements Nos. II and III giving, respectively, the figures for the plumb-line and the pendulum observations, and the mean values for each group of stations.

TABLE II.

Estimated deficiency of mass, over the Gangetic trough expressed in feet thickness of rock of average density, which would account for the residuals of deflection (after Sir S. G. Burrard).

No. of Section.	Stations north of the trough.		Stations over the trough.		Stations south of the trough	
I	Kurseong . .	5,000	Chanduria .	6,000		
II					Hurilaong . .	7,500
					Chenduar .	6,000
III	Birond . . .	5,000				
			Garwani .	15,000		
IV	Mussoorie . .	8,000				
	Dehra Dun . .	7,000				
V			Amritsar . .	7,500		
Means.		6,250		9,500		6,750

TABLE III.

Estimated deficiency of mass, over the Gangetic trough, expressed in feet thickness of rock of average density, which would account for the anomalies of gravity (after Sir S. G. Burrard).

No. of Section	Stations north of the trough.		Stations over the trough.		Stations south of the trough.	
I	Sandakphu . .	7,000				
			Siliguri . .	3,000		
			Jalpaiguri . .	2,000		
					Kisnapur	7,000
II			Gorakpur .	6,000		
			Majhauli Raj .	5,000		
			Muzaffarpur	4,000		
			Arrah	7,000		
					Ranchi	10,000
IV	Mussoorie . .	6,000				
	Rajpur . . .	4,000				
	Dehra Dun . .	4,000				
			Roorkee .	3,500		
			Kalianna	1,200		
			Gesupur . .	1,200		
V			Pathankot	5,000		
					Mian Mir .	7,000
Means .		5,250		3,800		8,000

The most conspicuous feature in these figures is the want of accord between the results obtained from the different groups of figures, and different means of observation. The plumb-line observations over the trough give higher figures, by nearly one-half, than those in the regions to the north and south, and in the case of the pendulum, a discrepancy in the opposite direction. If the results from the two different forms of observation are averaged, the means come much closer into agreement with each other, the figures being a deficiency of, in round numbers, 5,800 feet from stations north, 6,700 feet from stations over, and 7,400 from stations

south of the trough, but the justification of this method is very doubtful, owing to the different degrees of trustworthiness in the different groups of stations of the figures obtained from the two methods of observation. Over the trough the effects, both of the deficiency of density in the alluvium and of the excess in the compensation, are nearly directly under the station and will, therefore, be more direct and effective in the case of the observations of the pendulum than of the plumb-line. In the case of stations outside the trough the reverse is the case, the effect being more direct on the plumb-line than on the pendulum.[1] An arithemetical mean of the two would therefore, not be correct, a weighted mean should be used but it would be difficult to give proper weights to the values derived from the different methods of observation. In the case of stations outside the trough a ratio of 2 : 1 might be sufficient, but over the trough it should be larger, to what extent it is dificult to say. Probably the safest method would be to take the plumb-line observation for stations outside, and the pendulum observation for those over the trough ; in this case the figures would be 6,250 and 6,750 for stations north and south of the trough, and 3,800 for those over it.

The magnitude of the discrepancy suggests that the supposition, on which the calculations are based, is at fault and that part only of the residuals in the regions outside the trough, or in the region over the trough, are due to the deficiency of mass represented by the lesser density of the alluvium, the remainder being due to some other cause ; or it might be that this other cause was operative in opposite directions in the region over the trough, and in those outside of it. One such cause, which could produce the desired effect, would be a departure from the level of equilibrium, between topography and compensation, such as has been suggested.

The discrepancies shown by the mean values come out with equal or greater conspicuousness when the pendulum observations, which give a more or less complete series on the sections I, II and IV, are considered. In all of these three the discrepancies in the

[1] The mean width of the trough is about 120 miles, the maximum depth being at about 40-50 miles from the northern edge, and the depth of compensation assumed is about 70 miles. From this it follows that the resultant attraction at stations outside the trough would be inclined at angles less than 45° from the horizontal at stations outside the trough, and more than 45° at stations over the trough, the excesses and defects being, on the average, very considerable. The vertical component is, consequently, the more effective at stations over the trough, and the horizontal at stations to the north or south of it.

amount of the deficiency deduced, and the systematic character of the variation, could be accounted for by the adoption of an hypothesis of alternate zones of super-elevation and depression, as suggested in the Memoir, which would tend to equalise the estimates of the deficiency of mass in the alluvium by reducing the larger and increasing the smaller. Without going further into this matter, it is enough to point out that the discrepancies at least establish the same conclusion as is proved by Col. Cowie's calculations, that the residuals, of deflection and anomaly, cannot be attributed solely to the effect of the alluvium, but must be in part due to some other cause or causes.

Before dealing with the third of the new contributions of knowledge, mentioned at the outset, it will be well to recall that part of the Memoir which points out that if the suggested cause, for the alternate belts of super-elevation and depression, is accepted we should expect that the excess of mass in the outer Himalayas would not continue over the whole range, but would disappear in the interior, and possibly be replaced by another belt of defect, marked by negative residuals of anomaly. At the time when the Memoir was undertaken no observations were available except the somewhat uncertain one by Basevi, at Moré. It was pointed out that this indicated a Bouguer anomaly of about —·43 dyne, and, by a process of extrapolation, a perfectly justifiable method when used with discretion, it was concluded that the allowances to be made for compensation would be of about the same magnitude.[1] Since then this allowance has been computed in detail, the result has been announced by Sir S. G. Burrard in an indirect form,[2] the Bouguer anomaly being given as —·419 and the Hayford as +·018 dyne; the discrepancy between the Bouguer value, as given in the Memoir and by Sir S. G. Burrard, is easily accounted for, and need not be considered further, as it is not greater than the inherent uncertainty of the observation; but the difference between the Bouguer and Hayford anomalies gives the allowance for compensation as +·437 dyne. This figure will be useful when considering the observations made by Prof. Alessio in the course of the Filippi expedition to Central Asia.

[1] See *loc. cit.*, p. 111.
[2] *Geog. Journ.*, Vol. LVI, p. 49 (1920)

TABLE IV.

Deflection of the plumb-line, determined by Prof. A. Alessio on the Filippi expedition to Central Asia.

Station.	Lat.		Long.		Elev.	Deflections	
	°	′	°	′	m.	″	″
Rimu	35	21	77	39	4,912	9·8 N	
Dipsang	35	17	77	58	5,359	2·9 N	5·8 E
Leh	34	10	77	35	3,579	14·5 N	10·5 E
Lamayuru	34	17	76	16	3,450	6·3 S	9·2 W
Kargil	34	34	76	7	2,713	0·9 N	9·9 W
Skardo	35	18	75	39	2,233	28·3 S	10·9 E
Vozul Hadur	35	12	75	32	4,243	25·7 S	

TABLE V.

Gravity observations by Prof. A. Alessio on the Filippi expedition to Central Asia.

Station.	Lat.		Long.		Elev.	g*	γB	g − γB*
	°	′	°	′	m	dyne.	dyne.	dyne.
Kashgar	39	28	75	59	1,312	979·537	979·860	—·323
Yarkand	38	24	77	16	1,200	9·530	9·988	—·458
Sujet Karol	36	21	78	2	3,658	8·741	9·166	—·425
Dipsang	35	17	77	58	5,359	8·165	8·700	—·535
Leh	34	10	77	35	3,519	8·529	8·967	—·438
Lamayuru	34	17	76	17	3,450	8·575	8·990	—·415
Kargil	34	34	76	7	2,713	8·845	9·158	—·313
Skardo	35	18	75	39	2,233	8·920	9·315	·391
Vozul Hadur	35	12	75	32	4,243	8·536	8·911	—·375
Tolti	35	2	76	6	2,409	8·853	9·259	·406
Dras	34	26	75	45	3,081	8·778	9·074	—·296
Srinagar	34	4	74	50	1,590	9·090	9·338	—·248

* Figures in these columns require a correction of —·016 to bring them into accord with the Survey of India determinations of gravity.

The observations, of deflection of the plumb-line and of the force of gravity, were made at thirteen stations in the Himalayas and the Central Asian plateau. Only the figures directly derived from observation have been announced, so the deflections are not usable for the present purpose ; they suggest the existence of a belt of southerly residuals, to the south of the axis of maximum elevation of the surface, and northerly residuals to the north, but no dependence can be placed on this suggestion until the effect of topography and its compensation has been worked out in detail. The gravity observations are similarly given as the observed values, accompanied only by the theoretical value, with the free air correction applied. In this case it is easy to compute the Bouguer correction for masses below the level of the station and this has been done ;[1] the figures are given in the tabular statement below. The values of the Bouguer anomaly for the stations printed below Leh and Lamayuru, indicate a general decrease in the defect of mass from the central stations outwards, towards the margin of the hills, which suggests that the application of the correction for compensation will result in positive anomalies at the outer stations and negative, or at least smaller positive, anomalies at the inner ones, but as no estimate, even approximate, of the amount of the correction can be made till it has been computed in detail, no use can be made of these stations. Moreover, all these stations are situated in the re-entrant angle, between the terminations of the Himalayan and Hindu Kush systems of ranges, where the physical conditions would be less simple than along the Himalayas proper. This objection does not apply to the stations at Dipsang and Leh, or, to a lesser extent, at Lamayuru. At the latter two stations the compensation correction is not likely to be materially different from that which has been computed for Moré, or about ·43 dyne, which is almost the same as the amount of the Bouguer anomaly ; consequently we may take it that the Hayford anomaly at these stations will not be large, whether positive or negative. At Dipsang the method, which gave a good approximation at Moré, is no longer applicable, it is probable that the allowance for compensation will be greater than at Moré or Leh, but improbable that it will equal the increase in defect indicated by the Bouguer anomaly, so that the resulting anomaly will probably be negative and may be large.

[1] Using the formula given by Capt. H. J. Couchman. *Surv. Ind. Prof. Paper* No. 15, p. 3, 1915.

However this may be, the observations clearly show that the large and increasingly large, positive anomalies, found at the Survey of India stations, near the outer edge of the hills, are not maintained, but disappear, in the central part of the range ; and beyond this it is not necessary to go.

From the foregoing particulars it will be seen that the fuller observations and computations now available, confirm the conclusions, drawn in the Memoir, from the approximate methods then alone available. These were that along the marginal portion of the mountains there was a zone of super-elevation where the underground defect of density, or compensation, corresponded to a lesser altitude than the actual height of the surface above sea level; that this super-elevation probably did not extend over the whole range, but disappeared towards the interior and might possibly be succeeded by a region where compensation was in excess, corresponding to a greater height of surface level than actually existed; that bordering the range, and following approximately the line of the alluvial deposits of the Punjab and Upper India, there was a belt of over-depression of the surface, where the compensation corresponded to a greater elevation of the surface level ; and that beyond this belt of over-depression there followed one of super-elevation which traversed the Northern part of the Peninsular rock area and passed, on either hand, under the alluvium of the rivers of the Punjab, and of the Ganges and Brahmaputra. It was also pointed out that, so far as the two zones of super-elevation and over-depression, adjoining the outer boundary of the Range, are concerned, the phenomenon is what would be expected if the elevation of the hills were due to some form of direct uplift, and the outer crust of the earth, resting on more yielding material, possessed a degree of rigidity which prevented it from immediately and fully taking up the flexure, induced by the process which led to elevation in the one region and depression in the other.[1]

[1] In addition to the evidence quoted in the Memoir, of similar conditions existing in other mountain ranges, reference may be made to the detailed computation, by Mr. W. Bowie, of certain gravity stations in the Alps (*U. S. Coast and Geodetic Survey, Special Publication*, No. 40, 1917). According to these a group of five stations round and about Zermatt, in the southern and outermost range, gave anomalies ranging from +·044 to +·057, with a mean value of +·051 ; while five others, in the region of the Bernese Oberland, about 30 miles further into the range, gave anomalies ranging from —·010 to +·013 with a mean value of +·002.

Recently there has appeared the account of some observations which are instructive as an illustration of the processes involved in the explanation referred to above. It is well known that the working out of coal seams underground leads to settlement of the surface, and, in a recent (Oct. 1922) discussion of this subject, at the Institution of Mining Engineers, Mr. Wallace Thorneycroft contributed some observations which had been made by him over a long series of years, according to which the long wall system of coal mining is accompanied by a surface wave of uplift over the still unworked coal in advance of the working face, and a depression in rear of it, where the coal has been worked out.[1] The cause of the latter is obvious, in the loss of support due to the removal of the coal-seam ; the former can only be attributed to a degree of rigidity of the rocks overlying the seam, which transmits part of the flexure, caused by loss of support behind, to the untouched rock, in advance of the working face, and so leads to a bending upwards at the surface of the ground. If this effect can be produced in the comparatively thin and weak layer of rock overlying a workable coal-seam, it is not unreasonable to suppose that a similar effect would take place where the much thicker, and certainly stronger rocks, of the earth's crust as a whole, are concerned.

These observations come opportunely as an illustration of part of the processes involved in the uplift of a great mountain range, as it has been developed in this investigation, which may be taken as a contribution to our knowledge of the mechanism, though not of the ultimate cause, of the origin of mountains and, indirectly, of the major relief of the outer surface of the solid earth.

[1] *Colliery Guardian*, 24th Nov. 1922, p. 1276.

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RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1923 [December

ERNEST (WATSON) VREDENBURG, B.-ES-L., B.-ES-SC. (FRANCE), A.R.S.M., A.R.C.S., F.G.S., F.A.S.B. BORN 17TH APRIL 1870: DIED 12TH MARCH 1923.

IT is with much regret I have to record the death of Mr. E. W. Vredenburg, the most senior member of the Geological Survey of India. Mr. Vredenburg was educated at the Clermont University of France, and after working for a short time as Assistant Chemist in the Creusot Iron Works in France, joined the Royal College of Science, London, where he took the advanced courses in the various branches of Geology. He and Mr. Grimes were appointed Assistant Superintendents in the Geological Survey of India, and joined the office in Calcutta, which at that time was situated in the old Museum building, on the 16th October 1895. Both young officers were sent for their first camp season under Mr. R. D. Oldham to Rewah, where the party was greatly handicapped by a phenomenally unhealthy season.

His first official publication in India was a memoir entitled "A Geological Sketch of the Baluchistan Desert and part of Eastern Persia", which appeared in 1901; he also, together with Mr. P. N. Datta, assisted Mr. R. D. Oldham in a memoir, which appeared the same year, on the Geology of the Son Valley. Towards the close of 1903, after eight years' service, he was promoted to the grade of Deputy Superintendent, the initial salary of which post was then Rs. 500 *per mensem*. Early in 1903 he also acted as Curator, and in 1906 was appointed Palæontologist, a post which he has filled during the greater part of the rest of his service. Twice he

performed the duties of Lecturer in Geology at the Presidency College, Calcutta, and in 1913 was appointed Calcutta University Lecturer in the same subject. He was again promoted in 1910 to the grade of Superintendent.

There are few parts of India in which Mr. Vredenburg has not worked, and gifted as he was with a facile pen, his contributions to Indian geology number some three Memoirs and forty-nine papers in our Records, besides several unofficial papers. Two important palæontological memoirs of his are still in the Press, and several smaller papers are in course of publication. His best known piece of stratigraphical work is that on Baluchistan, which included some intricate mapping. Mr. Vredenburg's energies were, however, devoted chiefly to the subject of Palæontology, and our knowledge of Indian Tertiary rocks, especially those of Burma, has been clarified and made orderly by much laborious and painstaking work on his part. He was an indefatigable worker, and there is little doubt that his irrepressible energy prematurely consumed his vital resources and shortened an intensely active life. A burning enthusiasm, which made him somewhat impatient of criticism and intolerant of official interference, led him on at a pace which some were apt to mistrust, but which usually resulted in new conceptions and fruitful suggestion. His versatile powers made him an able speaker, a clever linguist, an enthusiastic collector of *objects d'art*, and, above all, a brilliant pianist. Those who had the pleasure of listening to his playing will not readily forget his reproduction of the Waldstein Sonata or the many works of Chopin to which he was so partial. Mr. Vredenburg, who had been ailing for some time, died on leave in London on the morning of the 12th March at the age of 53 years.

E. H. PASCOE.

FOSSIL MOLLUSCS FROM THE OIL-MEASURES OF THE DAWNA HILLS, TENASSERIM. BY N. ANNANDALE, C.I.E., D.SC., F.R.S., F.A.S.B., *Director, Zoological Survey of India.* (With Plates 6 to 7).

TWO collections of fossil molluscs from the Dawna Hills in Tenasserim have been submitted to me for examination, one by Professor J. W. Gregory, F.R.S., of Glasgow University, the other by Dr. G. de P. Cotter of the Geological Survey of India. The two collections include specimens of the same species, and each supplements the other in a very satisfactory manner.

The shells are all lacustrine or fluviatile and probably all belong to well-known freshwater genera still common in Tenasserim. One species, indeed, I have not been able to differentiate from a living form widely distributed in Burma, Assam and northern India. This is the Unionid *Indonaia bonneaudi* (Eydoux). The others appear to be extinct, but, in our general ignorance of the extinct freshwater fauna of any part of Burma except the Shan Plateau, provide little or no evidence as to the age of the beds in which they occur, except as showing that these beds cannot be very ancient. The molluscan fauna of the Shan Plateau is remarkably distinct as regards aquatic species from that of other parts of Burma and what little evidence we possess seems to indicate that it has been distinct from a comparatively ancient date. The fossil species from the oil-measures of the Dawna Hills, at any rate, exhibit no relationship to those described from the Northern Shan States.

In the two collections I find shells of four species of Gastropods and three species of Pelecypods. One of the Gastropod species is a little dubious and may be no more than a variety of another, which is evidently variable. The two forms undoubtedly belong to the Melaniid genus *Acrostoma* and are related to living Burmese species. The other two Gastropods apparently belong to the genus *Vivipara* (=*Paludina* of many authors), but are very distinct from any known recent or fossil form. They seem to be related distantly, however, to living Chinese species.

Of the three Pelycepoda all belong to the family Unionidæ and would until recently have been referred to the genus *Unio*,

which has now been split up on both conchological and anatomical grounds into many genera. The only form that can be referred with certainty to its proper genus is *Indonaia bonneaudi.* The other two I have assigned provisionally to recent genera on account of their resemblance, which may be superficial, to living species; but unless the hinge is exposed such generic identifications cannot be more than provisional. The species are undescribed and I have called them *Indopseudodon* (?) *rostratus* and *Lamellidens* (?) *quadratus.*

Family MELANIIDÆ.

ACROSTOMA INTERMEDIUM, sp. nov.

(Plate 7, figs. 1, 1*a*).

This species is represented by numerous specimens in both collections.

The shell is intermediate in structure between two living Burmese species, *A. variabile* (Benson)[1] and *A. elongatum* (Annandale)[2], but differs from both in its less impressed suture.

It is of comparatively large size and of narrow and elongate form, with the body-whorl not at all inflated and tapering gradually and evenly as a whole. None of the specimens are complete, but to judge from impressions in the stone the apex was sharply pointed and there were probably about 11 whorls. The aperture is relatively small, narrowly ovate and apparently not very oblique. It is broken in all the specimens, but the outer lip appears to have been sinuous and a little everted at its base. The columela is strongly arched. The sculpture consists primarily of numerous more or less curved costæ, which vary considerably in number, proximity and development. They do not reach either the upper or the lower margin of the whorls and often have a C-shaped form. At least traces can be seen upon them of three spiral rows of small tubercles, one median, the other two subterminal, and when these are well developed they are joined together in each row by smooth,

[1] See Hanley and Theobald, *Conchologia Indica,* pl. cix, figs. 2, 3, 5, 6; pl. lxxv, fig. 6.

[2] Originally described as *Melania baccata* var. *elongata,* but quite a distinct species. See Annandale, *Rec. Ind. Mus.* XIV, p. 115, pl. xii, figs. 3-7: also Ehrmann, *Sitz. Natur Ges. Leipzig.* XIV, p. 23, pl., fig. 8.

spiral ridges, which thus form a reticulate pattern. Below the costæ on the base of the shell there are five or six smooth spiral ridges.

Large shells when complete must have been about 60 mm. long and the maximum transverse diameter is 20 mm.

The *type-specimen* has been returned to the Geological Department of the University of Glasgow, while paratypes have been preserved in the collection of the Geological Survey of India.

I have already indicated the relationships of this species to living Burmese forms. It resembles my *A. elongatum* from the Southern Shan States in having three rows of tubercles on the costæ, but was probably almost as variable in sculpture as *A. variabile*, which has a much wider distribution. I am not able to find any close resemblance to any other fossil species except to one from the Pegu beds referred provisionally to *A. variabile*. The species is not allied to any of the fossil forms described from Java by von Martens.

ACROSTOMA COTTERI, sp. nov.

(Plate 7, figs. 2, 3.)

This form is represented by a single broken shell in Dr. Cotter's collection and another in Professor Gregory's. It may be merely a variety of *A. intermedium*, but the shape does not seem to be quite the same and the sculpture differs from that of any other specimen examined. The shell seems to taper more rapidly from the base and the last three whorls, which alone remain, are decorated with numerous curved ribs the bases of which form a series of small but prominent tubercles. These, seen under a lens, have almost a squamose appearance and may have been produced into spines in the fresh shell. The ribs do not occupy the full depth of the whorl but end abruptly a short distance from the suture both above and below, leaving a smooth band. This band slopes inwards slightly so that the suture, which is linear, lies at the base of a V-shaped groove. In the younger part of the body-whorl the ribs gradually become obsolete. Below the line of tubercles on this band, at the base of the shell, there are three prominent smooth spiral ridges.

The *type-specimen* is retained in the collection of the Geological Survey of India.

The shell somewhat resembles that of the living *A. brookei* (Reeve)[1] from Sarawak, but the tubercles at the base of the ribs have a different character and in *A. brookei* there do not appear to be any prominent ridges on the base of the shell.

Family VIVIPARIDÆ.

VIVIPARA DUBIOSA, sp. nov.

(Plate 7, figs. 4, 4*a*.)

The species is evidently abundant in the rocks examined. I am not altogether free from doubt in placing it in the genus *Vivipara*. In several of the specimens there are traces of what appears at first sight to be a testaceous operculum, but the plate has no particular structure and is always slightly concave on the external surface. I think it must be a fragment of another shell thrust into the aperture from outside. It is too big to be part of an embryonic shell. Moreover, the columellar region, which is preserved almost intact in two specimens, appears to be that of a *Vivipara*. Unfortunately the lip is broken in all the shells examined.

The shell is small for *Vivipara* and of rather unusually elongate conoidal form with a bluntly rounded apex. Its outline is conoidal. There are 5½ whorls, the apical half whorl having the form of a flat band. They increase rapidly but regularly in size, are but little oblique and have their outlines moderately convex. The suture is linearly impressed and the upper margins of the whorls are very narrowly flattened outside it. The spire and the body-whorl as seen in dorsal view are subequal in length. The penultimate whorl is relatively large. In ventral view the upper part of the body-whorl is convex while the lower part recedes somewhat. In young shells, but not in those of adults, there is a slight peripheral carina on this whorl. The mouth of the shell appears to have been ovate and oblique, but is broken in all the specimens. The columella is nearly straight and is provided with a slight, ridge-like fold. The umbilicus is rimate. The sculpture consists of strong, curved, longitudinal striæ set fairly close together. The external surface is very well preseved in some of the shells.

Adult shells are about 16 mm. long with a maximum diameter of 11 mm.

[1] See Brot in Martini and Chemnitz's *Conch. Cab.* (ed. Kuster), *Die Melaniaceen*, pl. xii, fig. 4.

The *type-specimen* has been returned to Glasgow Universty while paratypes have been retained for the Geological Survey of India.

Possibly the species is remotely related to *V. bugtica* (Blf.) from Baluchistan, but I know of no close fossil ally. If it is really a *Vivipara* it is distantly allied, so far as conchological evidence goes, to the living Chinese species of the *V. angularis group.*

V. dubiosa is more abundantly represented in Professor Gregory's collection than any other and seems to have been present in all the fragments of rock sent me.

VIVIPARA GREGORIANA, sp. nov.

(Plate 7, figs. 5, 5*a*.)

This species is represented by a practically complete shell and several broken shells in Dr. Cotter's collection and by several broken shells in Professor Gregory's. It seems to have been rather scarce.

The shell, though larger than that of *V. dubiosa*, is rather small for a *Vivipara* and very elongate. It is accuminate and tapers gradually to the apex. The outline is narrowly conical and very uniform, the suture being linear and not much impressed and the whorls hardly at all inflated. There are 6 whorls. The apical whorl is minute ; the others increase in size regularly and gradually. The fourth and fifth whorls are relatively deep. The body-whorl is transverse but increases in depth considerably towards the mouth. Its ventral surface is convex above and recedes rapidly below. The mouth, which is not quite complete even in the type-specimen, seems to have been small and oblique, rather narrowly ovate, sharply pointed above and rounded below. The umbilicus seems to have been rimate and the columella short and strongly curved. The peristome was probably incomplete. The sculpture consists of sparse irregular, longitudinal curved striæ or fine ridges. No spiral sculpture can be detected. The following are the measurements of the type-specimen. An incomplete shell in Professor Gregory's collection was probably larger.

	mm.
Height	**22**
Maximum diameter	**14**
Approximate—	
Height of mouth	**9**
Maximum diameter of mouth	**6**

Type-specimen in the collection of the Geological Survey of India.

This shell closely resembles that of the preceding species (*V. dubiosa*) but is much larger, more acuminate and more conical.

Family UNIONIDÆ.

INDONAIA BONNEAUDI (Eyd.).

(Plate 7, figs. 6, 7.)

1915. *Nodularia (Nodularia) bonneaudi* Preston, *Faun. Brit. Ind. Freshw. Moll*, p. 140.

1922. *Indonaia bonneaudi*, Baini Prashad, *Rec. Ind. Mus.*, XXIV, p. 95.

Professor Gregory collected a single valve and Dr. Cotter three valves which I am unable to distinguish from recent specimens of this variable species. In one of Dr. Cotter's specimens (a left valve) the hinge is exposed. It is somewhat worn and the posterior cardinal tooth is very prominent, but in the latter respect there is much variation in fresh shells. The four fossil examples exhibit considerable variation in outline, especially in respect of the prominence of the umbonal region.

I. bonneaudi is widely distributed as a living mollusc in Burma and Assam and also in northern India. It is, therefore, interesting to note that it has existed for a long period and has had time to spread.

INDOPSEUDODON (?) ROSTRATUS, sp. nov.

(Plate 6, figs. 1, 1*a*.)

The species is described from several practically perfect shells with the two valves in close contact.

The shell is large and solid, 66 mm. height, 100 mm. broad, 13 mm. thick. It has an irregular rostrate outline owing to the production of the posterior part and the sinuosity of the lower margin. The umbonal region is broadly convex and not at all prominent. Behind it there are indications of a low, elongated wing, but this structure is poorly developed and little differentiated, the valves being barely elevated and but slightly compressed. The posterior margin slopes downwards and backwards gently in a straight line for the greater part of its length and is there obliquely and forwardly truncate; the truncate region is short. The lower margin is trans

verse, but turns upwards somewhat abruptly to the anterior end. It is shallowly and broadly excavate in its posterior half, the excavation corresponding with a localized compression of the valves that does not extend up the shell for more than a third of its height. Anterior margin slopes forwards gently and is relatively short. The shell is neither inflated nor strongly compressed as a whole. Its upper surface is smooth (perhaps waterworn) and the only sculpture visible consists of coarse growth-lines on the lower parts. The valves gape slightly in front.

Type-specimen (labelled B. 67) returned to Glasgow University. Paratypes in the collection of the Geological Survey of India.

Remains of several other imperfect shells may belong to the same species. If so they indicate that the outline of the lower margin is somewhat variable.

The species appears to be allied to the living *I. salwenianus*[1] (Gould), but the shell is thicker and rather larger, has the umbonal region even less prominent and the posterior region more produced. Moreover, I can detect no trace of the characteristic sculpture on the posterior region.

On the surface of the type-specimen there are numerous minute granules that probably represent the gemmules of a sponge of the genus *Corvospongilla* or possibly *Stratospongilla* (see Pl. 6, fig. 2).

LAMELLIDENS (?) QUADRATUS, sp. nov.

(Plate 6, figs. 2, 2*a*.)

This species is also described from several practically perfect specimens. Its generic position is doubtful and could not be ascertained without examination of the hinges as it does not resemble any recent form at all closely. I do not think it belongs to *Unio*, *Indonaia*, *Parreysia* or *Indopseudodon* and *Lamellidens* is as probable as any other genus.

The shell resembles that of *I. rostratus* in some respects but is deeper in proportion to its height and not at all rostrate. It is large and solid, being 77 mm. high and 100 mm. broad and about 36 mm. thick. The outline is subquadrate, both extremities being broadly rounded while the upper and the lower margins are nearly equal and almost straight except at the anterior end, where they are somewhat curved and converge considerably. The umbonal region is

[1] See Prashad, *Rec. Ind. Mus.*, XXIV, p. 99 (1922).

convex and a little inflated, but not at all prominent. There are slight indications of a local constriction in the lower part of the posterior half of the shell. The wing on the upper margin is a little more developed than in *I. rostratus*. The only sculpture visible consists of strong growth-lines on the lower part of the valve.

Type-specimen (labelled B. 114) returned to Glasgow University. Paratypes in the collection of the Geological Survey of India

EXPLANATION OF PLATES.

PLATE 6.

(All the figures are of the natural size).

FIGS. 1, 1*a*.—Type specimen of *Indopseudodon* (?) *rostratus* Annand.
FIGS. 2, 2*a*.— Type specimen of *Lamellidens* (?) *quadratus* Annand.

(Both specimens are in the collection of the Glasgow University)

PLATE 7.

(All the figures, except when it is otherwise stated, are of the natural size).

FIGS. 1, 1*a*.—Type specimen of *Acrostoma intermedium* Annand. (In the collection of Glasgow University).
FIG. 2.—Type specimen of *Acrostoma cotteri* Annand. (In the collection of the Geological Survey of India).
FIG. 3.— Another specimen of the same species showing the ribs in better preservation. (In the collection of Glasgow University).
FIG. 4.—Type specimen of *Vivipara dubiosa* Annand. (In the collection of Glasgow University).
FIG. 4*a*.—Apex of the same specimen × 7.
FIG. 5.—Type specimen of *Vivipara gregoriana* Annand. (In the collection of the Geological Survey of India).
FIG. 5*a*.—Apex of the same specimen × 7.
FIGS. 6, 7.—Specimens of *Indonaia bonneaudi* (Eyd.). (In the collection of the Geological Survey of India).

NOTE ON AN ARMOURED DINOSAUR FROM THE LAMETA BEDS OF JUBBULPORE. BY C. A. MATLEY, D.SC., F.G.S. (With Plates 8 to 13).

IN a recent paper in the Records of the Geological Survey of India (Vol. LIII, pp. 142-164, 1921) the present author gave an account of his discovery of a large number of dinosaurian bones and scutes in the Lameta Beds at Jubbulpore, and at other localities in the Jubbulpore district. The remains were found most abundantly on the slopes of Bara Simla Hill, Jubbulpore, where bones of large sauropods (*Titanosaurus indicus* and other forms) were collected from the top of the Main Limestone and from the overlying marly and nodular beds. With them were associated a few parts of carnivorous (theropod) dinosaurs, chiefly detached megalosaurian teeth. Near by at the top of the greensand zone, immediately below the base of the Main Limestone, a large mass of bones was discovered that yielded thirty-two boxes of material, which were sent to London to be studied at the British Museum.

The first collection of material from this bone-mass was subjected to a preliminary examination by me before I left India, and it appeared to represent a single carnivorous dinosaur, as the limb-bones, vertebræ, teeth, metapodials, phalanges, etc., were all of a megalosaurian type, and no duplicate parts had up to that time been found. The occurrence of many small scutes and an occasional large one suggested that the remains of a stegosaurian might also be present, but as armoured dinosaurs had never been recorded from India, or from any other part of Asia, and as theropods were known in rare cases to possess scutes, as described by Osborn[1] and Gilmore,[2] I came to the conclusion that the scutes from Jubbulpore must belong to the carnivorous dinosaur with whose bones they were found.

The thirty-two boxes of material have been unpacked, and a portion of it prepared for examination. It is now evident that the remains do not belong to a single individual, but that portions of several megalosaurians are present, and that although the great bulk of the material belongs to carnivorous dinosaurs, some bones

[1] Osborn. *Bull. Amer Mus. Nat. Hist.*, Vol. XXI (1905), pp. 259-265.
[2] Gilmore, "Osteology of the Carnivorous Dinosauria, etc.", *U S. Nat. Mus.* Bull. 110 (1920), pp. 113-114.

of a large armoured dinosaur together with portions of the armour also occur. It is therefore very possible that the many small scutes several thousands in number, obtained from the bone-mass belong to a member of the Stegosauria. At any rate the supposed evidence for assigning them to a carnivorous dinosaur has vanished, owing to the discovery of stegosaurian bones.

The examination of the material had to be suspended owing to my leaving England to take up an appointment in Jamaica, and all that it has been possible to do up to the present has been to draw up a few notes on the stegosaurian bones recognised. Owing to the length of time that may elapse before the study of the material can be resumed, it is desirable to publish a preliminary account of this armoured dinosaur, as it not only possesses special characteristics but is the only individual of the armoured group that has yet been found in Asian deposits.

The remains consists of a sacrum, a pair of ilia, a left tibia, two lateral spines and many scutes. No doubt further portions of the skeleton will be discovered when the remainder of the material has been prepared and studied in detail.

SACRUM.

The sacrum is 61 centimetres in length and consists of five stout co-ossified vertebræ of sub-equal size. The ventral surface is in good preservation, but the neural arches are wanting, and the pleuropophyses of only one side have been preserved. The vertebræ are amphicœlous ; the concavity at the ends of the centra is slight. The sacrum resembles that of *Omosaurus* in its general aspect.

ILIA.

A pair of ilia were found with the sacrum, and are clearly stegosaurian, but differ from the known genera of stegosaurs in the greater prolongation of their post-acetabular portions, in which respect they approach the form of the ilia of *Triceratops.* They are distorted by crushing. The left ilium is 96 centimetres long when measured in a straight line, the acetabular portion, including the pubic and ischial processes, is 37 centimetres long, and 18 centimetres wide ; the pre-acetabular portion is $37\frac{1}{2}$, and the post-acetabular portion 28 centimetres in length. The processes for the ilium and pubis are short and stout. The general shape of the ilia approaches that of *Omosaurus.*

TIBIA.

There is a well preserved specimen of the left tibia. It is remarkably stout and straight with a great cnemial crest projecting forward and outward. It has a strongly marked facet for the fibula which must have been very large. The articulation for the femur is comparatively small, the outer condyle probably articulating mainly with the fibula. The shaft is flattened antero-posteriorly. The distal end is strongly compressed antero-posteriorly (so that its long diameter lies at right angles to the long diameter of the proximal end) and on the fibula side is produced downwards and slightly outwards. The astragalus is not present and was not co-ossified with the distal end of the tibia. The extreme length of the tibia is 58 centimetres, the minimum circumference of the shaft is 35½ centimetres. The proximal end measures 28 centimetres antero-posteriorly (*i.e.*, along the cnemial crest) and 12½ centimetres in the transverse direction across the femoral condyle. Its shape approaches that of *Omosaurus*.

SCUTES AND SPINES.

Scutes were found scattered promiscuously throughout the bone-mass in great abundance, and about five thousand were collected. They are extremely varied as to shape, size and thickness, but the great majority are small, not exceeding 20 millimetres in length. There is a small number ranging from 60 millimetres upwards, the largest being 120 millimetres in length. They are separable into many types which, however, are mostly connected by intermediate forms. The smallest specimen is 4½ millimetres long by 2½ millimetres wide and there are a number of slightly larger dimensions. Even these tiny scutes vary in shape, some being slightly longer than wide, with rounded edges and with a thickness nearly equal to the width ; others again are somewhat cylindrical and elongated with tapered or curved ends, or with one or more indentations or constrictions, or with the ends or margins run into one or more acute angles. In fact, these tiny scutes, up to 10 millimetres in length already show the outlines of several types found in the medium-sized and larger scutes.

The dominant form among the smaller scutes, up to a maximum of about 25 millimetres in length, is rhomboidal in shape, with well-marked concentric layers of growth. The base is flattened and usually irregularly wrinkled, and occasionally grooved, either

longitudinally or concentrically, the sides slope inwards to form a low convex, or flattened upper surface which is smooth save for the fine concentric lines of growth. A typical example measured $23\frac{1}{2}$ millimetres long, 17 millimetres wide and $10\frac{1}{2}$ millimetres thick. A well marked variant of this form is relatively thicker and sub-pyramidal in contour, and may be described as having the shape of a low truncated quadrilateral pyramid with chamfered edges.

Some of the scutes are thick tabular plates, while other tabular forms are so thin and delicate as to lead to the suspicion that they belong to a different kind of reptile. The collection also contains many other shapes, elongate, triangular, rectangular or irregular. Some scutes have sutures on one or more margins, or have the margins indented or running out into points. The larger scutes are not uncommonly tuberculate, the elevated tubercles being usually subcentral but sometimes eccentric ; rarely there are two tubercles on a single plate (Plate 12, Fig. 2). The ridged type of scute seen in *Polacanthus* has not been found. The bases of the scutes are usually flat or slightly concave, but are occasionally arched to fit on a markedly convex portion of the body.

A number of dermal spines are probably represented in the collection, but, as only two have been found with bases, the identification of the remainder is at present uncertain. The two figured are lateral spines and are remarkably like those of *Polacanthus*. The larger has an oblique base, is $14\frac{1}{2}$ centimetres long and 11 centimetres high. The smaller is $6\frac{1}{2}$ centimetres in length and 7 centimetres in height.

This Indian dinosaur differs from any hitherto described, but it approaches the genus *Omosaurus* in most respects. The nearest part of Gondwanaland from which stegosaurids have hitherto been obtained is Tanganyika. *Kentrurosaurus æthiopicus*, the only species yet described from that territory, differs both generically and specifically, from the Indian specimen as is evident from the tibia figured by Hennig.[1] As further parts of the Indian stegosaurian will probably be brought to light when the examination of the material from Jubbulpore is resumed, it is somewhat premature to make a generic diagnosis now, but it is desirable to give it a name for convenience of reference and I propose to call it *Lametasaurus*

[1] Edw. Hennig. "*Kentrosaurus æthiopicus* der Stegosauride des Tendaguru". *Sitzungber, der Gesellschaft Naturfor. Freunde zu Berlin*, No. 6, June 1915, pp. 219-247. (The generic name was changed to *Kentrurosaurus* in a later number of this publication).

indicus. The reptile is of Lameta age (probably Cenomanian or Albian) and occurs on the horizon of *Titanosaurus indicus*, *Megalosaurus* sp. and some undescribed sauropoda.

In conclusion I wish gratefully to acknowledge the facilities afforded me by Dr. A. Smith Woodward, F.R.S., to study these fossil bones at the British Museum of Natural History, and the skilled assistance of the staff in the preparation of the specimens. Both Dr. Smith Woodward and Dr. C. W. Andrews, F.R.S., have generously helped me with their special knowledge of fossil reptiles, a help all the more appreciated as I have only recently taken up the study of vertebrate palæontology. Finally, I wish to thank the Superintendent of the Gun Carriage Factory, Jubbulpore, for the facilities given for excavating the fossils found on the factory estate.

EXPLANATION OF PLATES.

LAMETASAURUS INDICUS gen. et. sp. nov., from Bara Simla Hill, Jubbulpore.

PLATE 8.

Sacrum—Scale about $\frac{1}{5}$.

FIG. 1. Lateral view.
,, 2. Ventral view.
,, 3. Dorsal view.

PLATE 9.

FIGS. 1 and 2. Right ilium distorted showing acetabular and dorsal aspects. Scale about $\frac{1}{7}$.

PLATE 10.

FIGS. 1 and 2. Left ilium distorted showing acetabular and dorsal aspects. Scale about $\frac{1}{7}$.

PLATE 11.

Left Tibia. Scale $\frac{2}{9}$.

FIG. 1. Outer side.
,, 2. Inner side.
,, 3. Anterior view.

PLATE 12.

Scutes and Spines.

FIG. 1. Small scutes. About natural size.

FIG. 2. Group of scutes viewed from the side to show elevation and thickness. Scale about $\frac{3}{8}$. Two of the figures exhibit two tubercles on one scute. In the top row is a specimen of a thick tabular scute.

FIG. 3. Two lateral spines, viewed from the sides. Scale $\frac{1}{5}$.

PLATE 13.

FIGS. 1 and 2. Two views of a group of large scutes showing the great variety of form. Scale about $\frac{3}{8}$. Fig. 1 depicts the upper surface, Fig. 2 the lower surface.

ON SOME FOSSIL FORMS OF PLACUNA. BY THE LATE E. VREDENBURG, B.-ES-SC., A.R.C.S., *Superintendent, Geological Survey of India.* (With Plates 14 to 18.)

THE genus *Placuna* is, at the present day, restricted to the eastern seas, and was unknown in a fossil condition until 1880, when Martin described some fossil specimens from Java that were referred to the living species *Placuna placenta* Linn. They were obtained by Junghuhn in the gorge of the Menengteng, where it is traversed by the Tji Scingarung, amongst strata which appear to be of Pliocene age (Martin, Tertiärschichten auf Java, p. 126, Pl. XX, figs. 13, 14).

In 1883, Fuchs described an extinct Miocene species, *Placuna miocenica*, from the collections obtained by Zittel during February 1874, in the oasis of Jupiter-Ammon (Sinah oasis); an occurrence which indicates, as remarked by Fuchs, that in Miocene times, the south-eastern Mediterranean regions were connected with the eastern seas. (Fuchs, *Palaeontographica*, Vol. XXX, p. 26, Pl. XIII (VIII), figs. 1-4.)

Fine specimens of *Placuna placenta* Linn. have been found in the Pleistocene deposits of the Pulicat Lake near Madras.

Four fossil forms of *Placuna* occur respectively in the Mekran beds of Jashk at the western extremity of the Mekran district at a Pontian or Pliocene horizon, in the upper Gáj beds of Sind which are presumably Burdigalian, in the Kama stage of Burma, approximately Aquitanian, and, again in Burma, presumably amongst beds of Oligocene age. All four differ from any species hitherto described.

PLACUNA (INDOPLACUNA) BIRMANICA.

Plate 14.

Medium size, orbicular, very flatly lenticular-concave-convex, umbo slightly deflected backwards, valves extremely thin, translucent, pearly, internally iridescent.

The right valve is externally flatly concave, internally flatly convex. Its hinge carries two pairs of ridges, the members of each pair uniting at an angle at the summit of the valve, and one system being superposed to the other in such a manner that the total number

of ridges seems, at first sight, to be only three, as the posterior ridges of both pairs coincide in position. The divergence, in the two sets, differs considerably, so that the anterior member of one of the pairs occupies an intermediate position between the two ridges of the more divergent pair, thereby producing the appearance that there are three converging ridges.

The ridges of the more widely diverging pair are relatively short, very thick and very prominent, and of approximately equal length. The angle of divergence of their external edge averages 103°. The ridges are not quite straight, the anterior ridge having a slightly convex outer margin, while the outer margin of the posterior ridge is distinctly concave. Consequently the angle of divergence, if measured at the apex of the junction of the ridges, would be less than 103°, approximately 90°, while if measured at the divergent extremities, it would amount to more than 103°. The amount by which the ridges are raised above the surrounding surface is approximately uniform, but their width or thickness increases from their divergent extremities, where they terminate in sharp points, towards the region of coalescence. This increase of width is especially marked and especially uniform in the anterior ridge; consequently, when the inferior margin of the ridges is considered, the ridges no longer seem sub-equal, but the anterior ridge seems to be the longer of the two, on account of the junction bend being removed further posteriorly as a consequence of the above-mentioned pronounced thickening. It follows further that the angle of divergence between the inferior margins of the ridges is still wider than that between their upper or outer margins. Moreover, the junction along the inferior margin is a curved bend, while along the upper margin it is a pointed angulation deflected backwards. The ridges adhere to the surface of the shell except at their divergent extremities where they terminate in sharp points or prongs, completely undercut and completely detached from the surface of the valves.

The above-described system is superposed to a second pair of ridges which diverge only at 37°. They are relatively narrower than those of the first system, longer, less prominent, quite straight. Their zone of junction is concealed by the first system. Their divergent extremities instead of being sharpened into detached points like those of the first system, simply merge gradually into the general inner surface of the valve. The posterior ridge of the second pair coincides in position with the posterior ridge of the first pair, but,

owing to the curved disposition of the more prominent ridge belonging to the first pair in contradistinction to the straight course of the narrower and less prominent ridge belonging to the second pair, the distinctness of both posterior ridges remains quite clear in spite of their superposition.

The umbo of the right valve exhibits, externally, the remains of the original foramen.

The left valve is externally convex, internally concave. When viewed on its internal side, the umbonal region appears surrounded on both sides by a moderately broad, flat foliaceous expanse formed by the superposed terminations of the successive layers of growth, analogous to the similar structure frequently observed in the corresponding umbonal portion of oyster shells. Towards the umbo, these foliaceous expansions enclose, on both sides, a sharply angular depression deflected backwards, in which fits the deflected angular junction of the first pair of ridges of the right valve. Below this angular depression, the inner surface of the valve is slightly uneven, but there are no distinct grooves such as would coincide with any of the ridges of the right valve. Quite close to the above-mentioned marginal foliaceous expansions, yet separated from them, for the greater part of their length, by a narrow space, are two extremely narrow, sharply prominent knife-edge ridges, rising perpendicularly, wall-like, from the surface of the shell, and diverging on either side from the umbonal apex. They include between them an angle of 104° and, when the valves are united, they are placed externally to the first pair of ridges of the right valve, closely fitting against them on either side.

The muscular impression, in either valve, is sub-central, moderately large, circular, extremely shallow, practically flush with the internal surface of the shell. The accessory muscle of the foot is not distinct in either valve of the solitary available specimen.

The external surface of both valves carries crowded concentric zones of growth, elegantly frilled, as is usual amongst the shells of this genus, by extremely fine, extremely crowded radiating delicate ribs.

Dimensions.	mm.
Umbonal-pallial diameter	87
Antero-posterior diameter	87
Thickness across united valves	5

Occurrence.—Mindegyi (19° 48′, 94° 53′). There are several fossiliferous zones at this locality ranging through a thickness of beds of nearly 2,000 feet, and, unfortunately, we do not know exactly the stratigraphical level that yielded the above-described shell. None but Oligocene fossils have hitherto been met with at Mindegyi, and there is every reason therefore to regard the above-described shell as of Oligocene age.

Comparison with other species.—The hinge of both valves differs remarkably from that of any other species hitherto described.

PLACUNA (INDOPLACUNA) PROMENSIS.

Plate 15.

Medium to large, conspicuously nacreous, translucent.

The right valve is flat. The chondrophores consist of two prominent, broad, coarsely rugose diverging ridges, superposed to a second pair of ridges which are smooth, less prominent, and more elongate. In the primary pair of ridges the anterior ridge is somewhat shorter than the posterior one. The ridges of the primary pair are both curved, though the curvature of the posterior ridge is very feeble. The curvature is similarly disposed in both, with the convexity turned anteriorly, so that the edge nearest the margin of the valve is the convex edge for the anterior ridge, the concave edge for the posterior one. Both ridges of the primary pair are terminated, at their free ends, by detached sharp points, the anterior ridge being, moreover, undercut for a considerable extent of its outer or anterior edge. The anterior ridge broadens considerably from its pointed termination towards the junction of the ridges. The posterior ridge has a more uniform breadth. The angula rapex of junction of the ridges is slightly damaged in the solitary available specimen, but appears to be only feebly deflected backwards. The angle included between the two primary ridges, if measured along their outer edges, is about 57°, when the measurement is taken at the free extremities about 60° at the apex. Measured along the inner edge of the ridges, the angle is wider in consequence of the broadening of the ridges towards the apex formed by their junction.

The ridges of the subsidiary second pair are to a great extent concealed by the superposed ridges of the primary pair, especially the posterior subsidiary ridge of which only the extreme termination is visible. The angle included between the ridges of the second pair

is smaller than that between those of the primary pair, and averages 32°. As the posterior ridges of both pairs are exactly superposed to one another, the anterior subsidiary ridge runs free for a considerable length from the superposed anterior primary ridge. Contrary to what is observed with the primary ridges, the subsidiary anterior ridge is longer than the posterior one. They do not rise abruptly from the shell-surface like those of the primary pair, but gradually merge into it along their edges and at their divergent terminations. Like the ridges of the primary set, they are slightly curved, the curvature, likewise, being most conspicuous in the anterior ridge. In consequence of the disposition of the curvature, and in consequence of the inner or inferior broadening of the anterior primary ridge, the anterior ridges of both pairs coalesce to a greater extent than might be gathered from the angular measurements of the respective convergence of either set.

The circular muscular scar is so shallow as to be scarcely noticeable.

The outer surface, examined with a magnifying glass, is seen to be entirely covered with thin, crowded, slightly wavy radiating ridges. The concentric markings are close-set and inconspicuous.

There is no available specimen of the left valve.

Occurrence.—Kyaungon (19° 30′, 95° 23′), at the horizon of the Kama Clay regarded as Aquitanian; collected by M. R. Ry. Sethu Rma Rau.

Comparison with other species.—There can be no doubt that this shell is related to *Placuna birmanica* of which it clearly reproduces the most noticeable feature, namely the presence of two pairs of converging ridges.

Specifically, the above-described species is easily distinguished from *Placuna birmanica* by the much closer convergence of the ridges.

PLACUNA (INDOPLACUNA) SINDIENSIS

Plates 16-17.

Medium-size to fairly large, orbicular, thin, translucent.

The right valve is concave internally, convex externally. The chondrophores consist essentially of two very prominent converging ridges of which the anterior one is much shorter than the posterior one. The average measure of the angle which they include is about 85°, but, in consequence of their curvilinear angle, the divergence, if

measured at their outer extremities, where they are furthest apart, amounts to 95°, while, where they are joined at the apex, the included angle is only 65°. At their outer extremities, both terminate in a sharp point detached from the adjacent surface of the shell. Except at its pointed extremity, the posterior ridge is everywhere attached to the shell. The anterior ridge, on the contrary, is entirely undercut for nearly half its length measured from its outer extremity. Both ridges are curved, the curvature being in both instances in the same direction, and disposed in such a way that the concavity of the posterior ridge and the convexity of the anterior ridge are turned towards the adjacent margins of the valve. The posterior ridge is somewhat crescent-shaped, tapering both towards its free posterior extremity and towards the apex where it joins the anterior ridge. From its anterior free pointed extremity, the anterior ridge rapidly widens and passes posteriorly into a broad plateau-like elevation which occupies the greater part of the space between the ridges, becoming less elevated and tending to merge into the general shell surface as it approaches the posterior ridge. Close to the anterior ridge, there issues from beneath this plateau-like swelling an apophysis which, in large specimens, may assume the appearance of a distinct intermediate subsidiary ridge, the direction of which converges towards the apex, forming, with the anterior ridge, an angle of about 30°. The principal muscular scar is sub-centrally situated, circular, and excessively shallow.

Externally, the umbo of the right valve exhibits very clearly the obturated remains of the foramen which characterised the "*Anomia*-stage" at early periods of growth, and the existence of which was first discovered by Fischer in the juvenile specimens of the living *Placuna papyracea* Lamarck.

The left valve is externally convex, internally concave. Its umbonal region carries, internally, a pair of diverging grooves essentially corresponding in shape and position with the ridges of the right valve.

The external surfaces of the valves, when examined with a magnifying glass, are seen to be covered with delicate crowded ribs diverging from the umbo. The concentric markings, fairly close-set, are not conspicuous.

Dimensions.—All the specimens of this species at present available are fragmentary. The valves grew to a diameter of at least 20 mm.

Occurrence.—West of Bhagothoro hill, in Sind, in company with *Ostrea latimarginata*, at the horizon of the upper Gaj regarded as Burdigalian. The *Placuna* mentioned by Blanford in the description of the geology of Western Sind (*Mem. Geol. Surv. Ind.*, Vol. XVIII), as occurring in the Gaj beds of the Dredhak stream, on the flanks of the northern part of the Khirthar range (*loc. cit.*, p. 84), further south close to Chorlo (*loc. cit.*, p. 118), and in the Kambú range (*loc. cit.*, p. 157), presumably represents the same species.

Comparison with other species.—This shell seems to be related to *Placuna birmanica*. It grows to a larger size. The angle of divergence of the chondrophores is smaller. The subsidiary apophysis of the right valve is almost certainly homologous with the more anterior of the second pair of ridges of *Placuna birmanica*; only, the posterior ridge of the second pair cannot be detected in *Placuna sindiensis*, and while the anterior ridge of the second pair approximately bisects the angle between the main ridges in *Placuna birmanica*, or is even situated closer to the posterior main ridge, it is, on the contrary, much nearer to the anterior main ridge in *Pldcuna sindiensis*. The divergence of the chondrophores, smaller than in *Placuna birmanica*, is nevertheless much greater than in *Placuna promensis*. Moreover, the independence of the subsidiary pair of ridges is much less distinct than in *Placuna promensis*.

Placuna miocenica Fuchs (*Pal.*, Vol. XXX, part 1, p. 26, Pl. XIII, figs. 1-4), from the Miocene of Egypt, is probably closely related to the species above described. One of the illustrations drawn by Swoboda (*loc. cit.*, fig. 2) shows a structure that seems to correspond exactly with the subsidiary apophysis of the Sind shell. If the accuracy of the illustrations may be trusted, the Egyptian form is clearly distinguished by the straightness of the posterior chondrophore ridge which is conspicuously curved in the Sind shell.

PLACUNA IRANICA.

Plate 18.

Medium to large, orbicular, relatively thick and relatively opaque.

The right valve is flat. The chondrophores consist of two relatively long ridges, equal, straight, diverging at an angle of 68°. They are attached to the shell and are terminated by blunt points at their outer ends, and are, otherwise, of fairly uniform width. Towards the apex a rather ill-defined raised area appears in the space inter-

vening between the ridges and assumes somewhat the appearance of an expansion of the anterior ridge. Externally the ridges are each bordered by a deep groove. The principal muscular scar is circular, rather deeply impressed and is situated somewhat nearer to umbonal than to the pallial margin, and also slightly nearer to the posterior than to the anterior margin. Close to the principal scar, along its anterior-inferior edge, a small crescentic depression represents the impression of the retractor muscle of the foot.

The left valve is feebly convex externally, with a shallow internal concavity. The umbonal region is internally traversed by two extensive diverging grooves corresponding with the ridges of the right valve. The muscular scars are slightly shallower than in the right valve.

Externally, the surface, when examined with a magnifying glass, is seen to be covered with close-set radiating ridges. The concentric markings are relatively wide-spaced.

The internal surface is rather brilliantly nacreous.

Dimensions.—The type-specimen, which includes both valves, has a diameter of 95 mm. The species also grew to much larger dimensions, attaining a diameter of at least 160 mm.

Occurrence.—East of Maihmani, Biyaban District, Jashk; presented by the Anglo-Persian Oil Company

The age of the specimens is Pontian or Pliocene.

Comparison with other species.—In its shape, its relative opacity, and the degree of divergence of its chondrophore ridges, the species above described recalls *Placuna Lincolni* Gray, living in Australia. It is distinguished by the straightness of the ridges which, moreover, are coarser than in the living form.

CONCLUDING REMARKS.

With the exception of the above-described *Placuna iranica*, all the extinct species known at present differ widely from the living forms, on account of the presence of a raised region occupying part of the interval between the chondrophore ridges, and owing to the presence of a more or less distinctly developed subsidiary pair of ridges less divergent than the primary pair. The fossil forms exhibiting these peculiar characters might be regarded as constituting a section "*Indoplacuna*," which does not seem to have survived the lower or middle Miocene, and was succeeded, in upper Miocene or Pliocene times, by forms analogous to the living types. The genus

Pseudoplacuna Mayer, 1876 (*Beitr. zur. Geol. Karte d. Schweiz*, XIV, p. 28, Pl. I, fig. 11), from the Eocene of Steinbach near Einsiedeln, is distinguished by its strongly biconvex shape. It is founded upon very imperfect material and the details of the hinge are unknown.

EXPLANATION OF PLATES.

PLATE 14.

FIG. 1*a*.—PLACUNA (INDOPLACUNA) BIRMANICA n. sp. Mindegyi. Right valve. Exterior. Natural size.

FIG. 1*b*.—Umbonal portion of the same specimen, enlarged $\frac{2}{1}$ to show the remains of the original foramen.

FIG. 1*c*.—Interior of the same valve. Natural size.

PLATE 15.

FIG. 1*d*.—PLACUNA (INDOPLACUNA) BIRMANICA n. sp. Mindegyi. Left valve. Exterior. Natural size.

FIG. 1e.—Left valve of the same specimen. Interior. Natural size.

FIG. 2.— PLACUNA (INDOPLACUNA) PROMENSIS n. sp. Kyaungon. Fragmentary right valve showing chondrophores. Natural size.

PLATE 16.

FIG. 3*a*.—PLACUNA (INDOPLACUNA) SINDIENSIS n. sp. West of Bhagothoro hill. Right valve. Exterior. Natural size.

FIG. 3*b*.—Umbonal portion of the same specimen, enlarged $\frac{3}{1}$ to show the remains of the original foramen.

FIG. 3*c*.—Interior view of the same specimen. Natural size.

PLATE 17.

FIG. 4.— PLACUNA (INDOPLACUNA) SINDIENSIS n. sp. West of Bhagothoro hill. Right valve of another specimen. Exterior. Natural size.

FIG. 5.— PLACUNA (INDOPLACUNA) SINDIENSIS n. sp. West of Bhagothoro hill. Fragmentary right valve showing chondrophores. Natural size.

FIG. 6*a*.—PLACUNA IRANICA n. sp. East of Maihmani. Right valve. Interior. Natural size.

PLATE 18.

FIG. 6*b*.—PLACUNA IRANICA n. sp. East of Maihmani. Left valve. Exterior Natural size.

FIG. 6*c*.—Left valve. Interior. Natural size.

ON THE PHYLOGENY OF SOME TURBINELLIDÆ.[1] BY THE LATE E. VREDENBURG, B.-ES-SC., A.R.C.S., *Superintendent, Geological Survey of India.* (With Plate 19.)

THE GENUS TURBINELLA.[2]

(a) *Indian Series.*

AN extremely valuable study dealing with the varieties of *Turbinella pirum*, the living "sankh" of the Indian Ocean, was published by James Hornell, in 1916, in the Memoirs of the Indian Museum.[3]

At the time of the publication of this work, I happened to be engaged on a study of the fossil post-Eocene Turbinellidæ of India, and I noticed the occurrence of a most remarkable succession of four mutually closely related mutations[4] ranging in geological age from Oligocene to uppermost Miocene. At the same time I noticed that the living *Turbinella pirum*, which is also known in a fossil condition from the Pliocene of southern India, differs so widely from the uppermost Miocene representative of the above-mentioned evolutionary series that it must be regarded as a member of a separate evolutionary series. The immediate ancestral forms of *Turbinella pirum* are as yet undiscovered and their region of origin is unknown. *Turbinella pirum* invaded the Indian seas in Pliocene times, and either from its more robust temperament or greater adaptability, seems to have finally displaced the last representative of the series, which for so long a succession of geological ages had occupied the shores of the Indian Peninsula, where it is now extinct.

Nevertheless, from a comparison with a specimen in the collections of the Indian Museum, and with the excellent illustration in Reeve's "Conchologia Iconica," it appeared to me that the last representative of the aforesaid series differed not more than varietally from

[1] Read at the Indian Science Congress at Madras in February 1922.

[2] Commonsense refuses to submit to such an absurdity as *Xancus* Bolten. I cannot accept any of the Bolten nomenclature, the adoption of which would reflect discredit on the genius of Lamarck.

[3] "The Indian varieties and races of the genus *Turbinella*." *Mem. Ind. Mus.*, Vol. VI, 1916, p. 109.

[4] The term "mutation" is used here in the sense originally defined by Waagen to signify a species or variety characterising one particular geological age, and which there is reason to regard as derived from a previous closely related parent form known to occur at an older geological horizon.

Turbinella ovoidea Kiener, now living along the coast of Brazil, and, according to Gabb and Tryon, occurring also in a fossil condition in the Miocene of San Domingo. On several occasions geologists have noticed a close resemblance between the Miocene fauna of India and that of the Caribbean region. This resemblance is perhaps to be accounted for by a mutual interchange across the Pacific region previous to the separation due to the formation of the Isthmus of Panama which only took place in post-Burdigalian times. The communication between the Indian Ocean and Mediterranean became increasingly obstructed in Miocene times, so that the resemblances between the Indian and Caribbean Miocene faunas are perhaps better explained by migration across the Pacific than across the Atlantic.

These various facts and conclusions have been discussed in a note which I appended to Mr. Hornell's study.[1] Since writing this note I have come across some excellent specimens of a Miocene *Turbinella* of San Domingo, labelled by Professor Gabb himself as *T. ovoidea*, and presented by him to the Geological Museum in Calcutta. The resemblance to the living form is very close, yet it does not amount to identity. The San Domingo fossil is an ancestral form which must be regarded either as an ancestral variety of *T. ovoidea*, or else distinguished as an ancestral premutational species. Moreover while evidently in the line of ancestry of *T. ovoidea*, it diverges from the above-mentioned Indian fossils rather more than the living form. The close resemblance noticed between *T. ovoidea* and the last mutation of the fossil series in the Indian region is somewhat of the nature of a convergence. The convergence is easily intelligible when we consider that both series, the Indian and the Caribbean, are very closely similar, constituting perhaps mere branches of a single stock. Yet, as the San Domingo fossil, which is the evident ancestor of *T. ovoidea*, must be regarded as specifically distinct from the various terms of the Indian series, *T. ovoidea* itself cannot be regarded as specifically identical with any of them.

As already explained in the note appended to Mr. Hornell's study, the successive mutations of the Indian series differ from one another mainly by the progressive dwindling of the raised decoration at later stages of growth. In the oldest form, *Turbinella*

[1] "Note on the geological history of *Turbinella* in India." *Mem. Ind. Mus.*, Vol. VI, 1916, p. 122.

episoma Michelotti which occurs in the Oligocene not only of India, but also of the Mediterranean region, the ribbed decoration of the earlier spire-whorls is continued, although attenuated and somewhat modified, on the later spire-whorls and body-whorl. At about half the height of the whorls, the ribs, at earlier stages, carry a swelling which is represented by an angulation on the later spire-whorls and body-whorl.

During the Aquitanian, or lower Miocene, *Turbinella episoma* was succeeded, in India, by *T. affinis* Sow. in which the ribs entirely disappear on the last spire-whorl and body-whorl, and the angulation, at these later stages of growth, becomes indistinct.

A closely related mutation occurs in India at a slightly higher geological horizon, in the upper Gaj, regarded as Burdigalian in age. Under the impression that the final upper Miocene mutation is specifically identical with the living *T. ovoidea*, I designated the Burdigalian form as *T. præovoidea* (a name which has remained merely a *nomen nudum*) in the note previously published, in which the upper Miocene form was regarded as a variety of *T. ovoidea*. As explained above, this specific identification can no longer be maintained and the upper Miocene Indian form must be regarded as a different species for which I propose the name of *T. mekranica*. The mutation that links *T. mekranica* to the lower Miocene *T. affinis* can no longer be known under the misleading name of *præovoidea* which I now propose to alter to *præmekranica*. As the shell has not been figured, taxonomists may perhaps forgive me this change of nomenclature.

In *T. præmekranica*, the ribbed and spiral ornaments disappear from the two last spire-whorls as well as from the body-whorl, and the angulation becomes still more attenuated than in *T. affinis*, often disappearing entirely on approaching the aperture.

Lastly, in the upper Miocene *T. mekranica*, the ribbed decoration becomes restricted quite to the apical portion of the shell. The four last spire-whorls, constituting the greater portion of the spire, exhibit an almost uniform smooth convexity continued on the body-whorl.

As already explained in the previously published note, I have not considered that the internal spiral plications are to be accounted as of much importance as evolutionary features. Their number may vary even amongst individuals of a single species as is known from the study of specimens of *T. affinis*.

There are always three internal folds in *T. episoma*, usually five in *T. affinis*, while *T. præmekranica* and *T. mekranica*, when full-grown, usually carry four of these internal ledges, of which, nevertheless, the most anterior one is often poorly developed.

As already mentioned in the note previously published, the close similarity between successive mutations is apt to give rise to some hesitation as to the nomenclature to be adopted. Any two immediately successive terms of the series might reasonably be treated as varieties of one species, but, if we omit one term, the preceding and the succeeding mutations unhesitatingly convey the impression of distinct species. Under the circumstances we can scarcely adopt any other practical course but to give a separate specific name to each term of the series.

T. mekranica represents the last stage so far observed in the evolutionary series followed through successive geological ages from the Oligocene *T. episoma* in Western India. At the present day, *T. mekranica* is replaced on the coast of the Indian Peninsula by *T. pirum* Linn. which already appears in the Pliocene of southern India where Cossmann has identified it in the fossil fauna of Karikal, and which cannot be regarded as a further evolutionary stage of the upper Miocene *T. mekranica*. Instead of the difficulty which is experienced in deciding whether two forms are to be treated as varieties or species, as when dealing with immediately successive mutations of the series *episoma-mekranica*, there can be no hesitation as to specific distinctness when comparing *T. mekranica* with *T. pirum*, which is distinguished at the merest glance by the straight or angular-convex profile of its spire-whorls, the spire thereby acquiring a generally subulate appearance quite different from that produced by the evenly convex whorls of *T. mekranica*. Apart perhaps from some quite exceptionally elongate specimens of the variety *acuta* Hornell, the outline of the spire, in *T. pirum*, never approaches in slenderness that characterising *T. mekranica*, and is even, in most instances, quite disproportionately depressed. Generally the shell exhibits a club-shaped or top-shaped outline, totally differing from that of *T. mekranica*. The ribbed decoration of the early spire-whorls persists to a somewhat later stage than in *T. mekranica*; a feature which, even leaving aside the conspicuous differences above enumerated, would argue against any probability of *T. pirum* being derived from *T. mekranica*. The number of internal spiral folds in *T. pirum* is four when the shell is full-grown.

There is nothing in the characters of *T. pirum* that might indicate any close relationship to the line *episoma-mekranica*, and its ancestral predecessors, in the nearer stages at least, must have differed from those of *T. mekranica*. *T. pirum* is probably an immigrant which, in Pliocene times, invaded the Indian region. The previous home of the predecessors of *T. pirum* is at present unknown. Much useful information on the phylogeny of many Indian shells may be expected when the Tertiary faunas of the southern hemisphere will have been more completely studied than at present.

The living fauna of the Andamans includes a remarkable *Turbinella* whose characters also preclude the possibility of its being regarded as an offshoot of the upper Miocene *T. mekranica*. This is *T. fusus* Sow., which Hornell rather hesitatingly classified as a variety of *T. pirum*, but which it seems best to treat as a distinct species. It differs conspicuously from *T. mekranica* by its stepped spire with a pronounced angulation continued on the body-whorl as far as the aperture. The ribbing of the apical region is more pronounced than in *T. mekranica*, and continues in a vestigial condition over the later spire-whorls and body-whorl. While this shell thus strongly differs from *T. mekranica*, it exhibits an extraordinarily close resemblance to the ancestral *T. episoma* of the Oligocene. In the shape and ornamentation there is scarcely any character that can be indicated as precisely distinguishing both species. The number of internal folds, invariably three in *T. episoma*, four or five in *T. fusus*, constitutes the only readily appreciable difference. Whilst, along the coasts of western India, the descendants of *T. episoma* constituted a constantly evolving series, it would seem that, in the region of the Andamans, the descendants of *T. episoma* have maintained their original characters almost unchanged to the present day.

(*b*) *American Series.*

In the note previously published, *T. mekranica* was regarded as a variety of *T. ovoidea* Kiener, now living along the coasts of Brazil. A specimen of *T. ovoidea* in the collections of the Indian Museum closely resembles *T. mekranica* though distinctly more elongated, while Reeve has illustrated a much stouter specimen of *T. ovoidea* which still more closely resembles the Mekran fossil. *T. ovoidea* has only three distinct internal ledges as compared with four in *T. mekranica*, in which, however, as already mentioned, the most

anterior fold is poorly developed. The greater elongation of *T. ovoidea* and the slight difference in the internal plication were originally treated by me as mere varietal characters. *T. ovoidea* is recorded both by Gabb and by Tryon as occurring in a fossil condition in the Miocene of San Domingo, and I came to the conclusion that the free communication that existed between the Caribbean and Pacific regions before the formation of the Panama barrier, could account for the occurrence of *T. ovoidea* and its variety *mekranica* respectively in the Caribbean and Indian regions, by means of migration along chains of islands across the Pacific.

As mentioned in a previous paragraph of the present note, I have, since publishing the above conclusions, come across some excellent specimens of the San Domingo fossil *Turbinella*, labelled and presented by Gabb. The resemblance of the San Domingo fossil to the living *T. ovoidea* is of the very closest, and there can be no question as to a very close relationship. It is obviously an ancestral pre-mutation of the living shell. In its ornamentation it very closely recalls *T. præmekranica* with which it is probably contemporaneous. Yet its much greater elongation as compared with the Indian fossil is so pronounced that the two can scarcely be specifically united. If then the earlier Miocene forms in the Indian and Caribbean regions are to be regarded as specifically distinct, we would not be justified in uniting specifically their respective descendants, although an attenuation of the degree of elongation in the living *T. ovoidea* induces a deceptive appearance of convergence towards the shape of the Indian *T. mekranica*. Like *T. ovoidea*, the ancestral San Domingo fossil has three internal folds instead of the four observed in *T. præmekranica* and *T. mekranica*.

When we come to the question of naming the San Domingo fossil, we are met with the same kind of difficulty as when dealing with adjacent terms within the *episoma-mekranica* series. The fossil certainly differs from the living *T. ovoidea*, yet we may hesitate as to whether the differences are sufficient to entitle it to rank as more than a variety. Its relationship to the living *T. ovoidea* is exactly the same as that recorded between *T. præmekranica* and *T. mekranica*. The ribbed ornamentation of the earlier spire-whorls remains quite distinct up to a diameter of sometimes as much as 28 mm. in the San Domingo fossil, the last spire-whorl and a varying portion of the penultimate spire-whorl being the only portions of the spire that are practically smooth. In the living *T. ovoidea*, just as in *T. mekranica*,

the ribbed decoration becomes restricted to an insignificant portion of the apex, and the ribs are absent from the three last spire-whorls.

The difference between the San Domingo fossil and *T. ovoidea*, though slight, is precise and constant. Gabb regarded both forms as specifically identical; yet the fossil should receive a separate designation, at least as an ancestral variety. As with the Indian forms the more practical course, to avoid a cumbrous nomenclature, is to distinguish it by a separate specific name. It so happens that this has been provided by Miss Maury in her study of a duplicate set of Gabb's fossils, published in 1917,[1] in which, unaware of my note published in the previous year, the author has precisely used the specific name *præovideus*[2] (*op. cit.*, pp. 83, 251). As used by me the name, as already stated, may be regarded as a *nomen nudum* and Miss Maury's designation is so excellently suited to the fossil under consideration that we cannot do better than adopt it.[3]

Turbinella ovoidea is undoubtedly a mutation derived from *T. præovoidea*, just as *T. mekranica* is undoubtedly a mutation derived from *T. præmekranica*. As already noticed, the greater elongation of *T. præovoidea* Maury is the principal difference that distinguishes it from *T. præmekranica*.

T. præovoidea so closely resembles *T. valida* Sow., also from San Domingo, that it might be regarded as a mere variety of that species. The persistence of a distinct shouldering and of small nodes on the later whorls of *T. valida* constitutes the only distinction. Nevertheless, according to Dr. Pilsbry, the difference, though slight, is constant (*op. cit.*, p. 344). Most probably *T. valida* belongs to a slightly different horizon. It differs from *T. præovoidea* in almost exactly the same way as *T. affinis* differs from *T. præmekranica*. Most probably therefore *T. valida* represents an ancestral predecessor

[1] "Santo Domingo Type Sections and Fossils." *Bull. Amer. Pal.*, Vol. V, pp. 1-251

[2] Used in the masculine with "*Xancus*".

[3] I was unaware of the existence of Miss Maury's monograph when writing the present paper. I became acquainted with it through the courtesy of Dr. Pilsbry who has presented to me a copy of his valuable "Revision of W. M. Gabb's Tertiary Mollusca of Santo Domingo," published in January 1922 (*Proc. Ac. Nat. Sci. Phila.*, 1921, part II, pp. 305-435). From the similarity of the early whorls, I had come to the conclusion that the San Domingo *Turbinella* represents the full-grown stage of *T. textilis* Guppy from the Bowden Marl of Jamaica, only known until lately from an immature specimen. I now find, from Dr. Pilsbry's monograph, that the full-grown stage of *T. textilis* is clearly distinguished from that of the San Domingo *Turbinella* by the presence of plications on the body-whorl (*op. cit.*, p. 343, Pl. XXV, figs. 5, 6).

of *T. præovoidea.* The resemblance between the American *T. valida* and the Indian *T. affinis* is just as close as between the American *T. præovoidea* and the Indian *T. præmekranica.* If the surmise be correct as to the slightly older age of *T. valida* relatively to *T. præovoidea*, we have here a most remarkable instance of parallel evolution respectively in the Caribbean and Indian regions. It may be particularly noticed that, under the mistaken impression of the identity of *T. mekranica* and *T. ovoidea*, I gave the same specific name *præovoidea* in the Indian series, as Miss Maury simultaneously bestowed upon exactly the same evolutionary stage, perhaps strictly contemporaneous in geological age, in the Caribbean series.

Another related Caribbean species is *Turbinella textilis* Guppy, from the Bowden Marl of Jamaica, regarded as approximately Burdigalian, and contemporaneous with a large portion of the fossiliferous series of San Domingo. It is clearly distinguished by the plications of its body-whorl (see Pilsbry, *loc. cit.*, p. 343, Pl. XXV, figs. 5, 6).

The magnificent *Turbinella regina* Heilprin, from the Pliocene of Florida, a species characterised by its extreme elongation, also appears to be another derivative branched off from the same stock.

Turbinella chipolana Dall (*Trans. Wagner Free Inst. Sci. Phila*, Vol. III, p. 97, Pl. X, fig. 7, 1890), from the Chipola and Oak Grove horizons of Florida, of approximately Burdigalian age, the adult of which does not seem to have been figured, may also represent another branch of the same stock. Judging from Dall's description, it has rounded-convex whorls. It is less elongate than *T. regina*, yet more elongate than any of the Indian fossil species. The ribbed decoration is restricted to a very small portion of the apex.

Several other species of *Turbinella* are known from the Tertiary of America. The oldest is *Turbinella wilsoni* Conrad from the Oligocene Vicksburg beds of the Mississipi region. (See *Journ. Ac. Nat. Sci. Phila.*, ser. 2, Vol. I, p. 120, Pl. XII, fig. 12, 1848.) According to Dall (*Trans. Wagner Free Inst. Sci. Phila.*, Vol. III, p. 96, 1890), it also survives into the Chipola beds of Florida, the age of which appears to be Burdigalian. Judging from the illustration published by Conrad, it resembles the oldest known Indo-Mediterranean species, *T. episoma*, from which, nevertheless, it is unquestionably distinguished by its much greater degree of elongation. It bears three internal plaits, like *T. episoma.* Whereas the successors

of *T. episoma* exhibit much variation in the number of internal spiral plaits, all the American forms constantly carry only three plaits. While this may not be a character of primary importance, yet, taken in conjunction with the constantly more elongate habit of the American forms, it tends to encourage the suspicion that the two series, American and Indian, may after all constitute entirely parallel lines of development, in which, nevertheless, the similarity in the evolutionary characters, and their correspondence at corresponding successive geological ages, constitutes a fact of the greatest interest.

The presence of only three internal spiral folds appears to be a primitive character in the genus *Turbinella*. Amongst the species with more than three internal spiral folds, all the immature specimens below a certain stage of growth that have come under my notice carry only three folds. With increasing growth, the supernumerary folds are developed in an anterior direction over the posterior portion of the columella.

The remaining fossil American species probably belong to a different group. They are characterised by the presence of a well-marked concave zone surrounding the suture over the greater part of the spire and on the body-whorl. They include *T. polygonata*, *T. rex*, and *T. scolymoides*. *T. polygonata* Heilprin (*Trans. Wagner Free Inst. Sci. Phila.*, Vol. I, p. 108, Pl. XV, fig. 43, 1887 ; Dall, *ibid.*, Vol. III, p. 97, 1890), the adult stage of which has not been figured, occurs in Florida, in the Ocala limestone of upper Oligocene age, the Tampa silex beds, approximately Aquitanian, and perhaps ranges into the approximately Burdigalian Chipola beds. *T. rex* P. and J., occurs in the Miocene of San Domingo and has been compared by Pilsbry with the living *T. scolymus* (*op. cit.*, p. 342, pl. XXVI, figs. 5, 8). *T. scolymoides* Dall (*Trans. Wagner Free Inst. Sci. Phila.*, Vol. III, p. 98, Pl. III, figs. 2, 5, 1890 ; p. 229, 1892) occurs in the Caloosahatchie beds of Florida, essentially Pliocene. According to Dall, it is also undoubtedly related to *T. scolymus* living on the coasts of Brazil, for which Swainson, in 1840, established the quite unnecessary genus *Scolymus*, merely on account of the presence of strong ribs on the body-whorl.

Apart from the well established evolutionary series *episoma-mekranica* and *valida-ovoidea*, the true relationships of the various fossils and recent species of *Turbinella* must remain largely problematical in the present state of available information. The following

tentative scheme should therefore be regarded as indicating resemblances rather than suggesting real affinities.[1] (See Plate No. 19.)

THE GENUS MELONGENA.

Other examples of evolutionary series analogous to the series *Turbinella episoma-mekranica* have been also observed, in the Indian Tertiary, within the family Turbinellidæ in the genus *Melongena.*

In 1901, Noetling described from Tertiary strata in Burma, now known to be Oligocene, a shell which was regarded as specifically referable to the living *Melongena pugilina*[2]. Though the characters of this fossil, when compared with those of the living shell, do not amount to complete identity, yet it exhibits a very close resemblance and undoubted relationship not only to the living *Melongena pugilina,* but also to one of the commonest fossils of the uppermost Miocene of Java and of the Mekran, *Melongena ponderosa* Martin (*Samml. des geol. R. Mus. in Leiden,* new series, Vol. I, p. 92, Pl. XIV, fig. 208). The resemblance between *Melongena ponderosa* and the living *M. pugilina* is even closer than between the living form and the Burma fossil. Still more than with the form described by Noetling, may we be allowed to hesitate as to whether *M. ponderosa* should be treated as a species distinct from *M. pugilina,* or only as an ancestral variety. Owing to the extremely close resemblance between *M. ponderosa* and *M. pugilina* the features that differentiate the Burma fossil from the one are the same that distinguish it from the other. The most obvious difference consists in the constantly wider-spaced spines of the Burma fossil, as compared with both the other forms under consideration. Moreover, as I have already pointed out on a previous occasion (*Rec. Geol. Surv. Ind.,* Vol. LI, p. 273), the spines, absent from a portion of the body-whorl in the Burma fossil, are also absent from a portion of the spire in the *M. ponderosa* and *M. pugilina,* though

[1] To construct this diagram, I have adopted the following approximate synchronisms for the Floridan and other related geological regions.

Caloosahatchie	Pliocene
Chesapeake	Vindobonian
Oak Grove Sands, with the Bowden marl of Jamaica and the corresponding portion of the fossiliferous San Domingo beds.	Burdigalian
Chipola beds	Burdigalian
Tampa silex beds	Aquitanian
Ocala limestone	Oligocene
Vicksburg beds	Oligocene

[2] *Pal. Ind.,* new ser., Vol. I, part 3, p. 315, Pl. XXI, fig. 2.

they reappear on nearing the aperture. The internal walls are lirate in the Burma fossil, while they are smooth in *M. ponderosa* and in *M. pugilina.* Lastly the spire of the Burma fossil is usually more elongate either than in *M. ponderosa* or *M. pugilina,* and the dimensions of the shell are generally less than in the living shell and especially in *M. ponderosa.*

The Burma fossil is therefore clearly differentiated. Yet, opinions may perhaps differ whether any of the differences above enumerated are of so pronounced a degree as to justify full specific separation. At the same time, if we accept Noetling's identification and regard the Burma fossil as no more than a variety of *M. pugilina,* we must *a fortiori* regard *M. ponderosa* also as a variety of the recent shell as the relationship is still closer. Compared with the living shell, *M. ponderosa* is distinguished by its more robust growth, the relatively thick shell-wall even of small specimens, and the somewhat steeper slope of the posterior concave portion of the whorls, the margin of which encroaches upon the preceding whorl more than is usual with the living form. Consequently the relative height of the anterior vertical portion of the spire-whorls is thereby slightly reduced.

I have already adopted the name *Melongena præponderosa* for the Burma fossil (*Rec. Geol. Surv. Ind.,* Vol. LI, p. 273). If we accept Noetling's conclusion in regarding it as specifically identical with *M. pugilina,* we will have to name it *Melongena pugilina* var. *præponderosa.* The upper Miocene *M. ponderosa* which there is ample reason to regard as a variety of the living species, would then become *Melongena pugilina* var. *ponderosa.* As in other similar instances if, for the mere sake of convenience, we treat the successive mutations as distinct species we shall avoid the awkwardness of a cumbersome nomenclature.

Another instructive instance of a close phylogenetic relationship between a living form and its fossil predecessor is afforded, also in the genus *Melongena,* by the living *M. paradisiaca* Martini together with a fossil from the Oligocene of Burma which I have designated as *M. præparadisiaca.* The fossil scarcely differs from the living shell otherwise than by its more elevated spire.

The Gáj beds of Sind, of lower Miocene age, have yielded a *Melongena* which does not differ from the living *Melongena galeodes* otherwise than by the feebler development of the spiral ornaments along the angulation of the body-whorl and over the region imme-

diately anterior to it, and which I have therefore regarded as a variety "*sindiensis*" of the recent species.

CONCLUDING REMARKS.

The gradual transformation of one species into another may have been, in some instances, a continuous process, each generation differing very slightly from its predecessor and successor. The study of fossil organisms has shown, however, that in many cases, the process of evolution has been discontinuous. We may find a particular form with well established characters that remain fixed throughout a certain geological period and over a considerable geographical area. It is succeeded by another related form, diverging more or less from the parent species, and, in its turn, preserving fixed characters throughout a geological period of considerable duration. In comparison with the longevity of both forms, the period of transformation must have occupied a comparatively limited number of generations. The distinction between two successive mutations, even when quite definite, is often so slight as to be scarcely within the limits of specific difference. Yet, when more than two successive mutations are known, the increasing divergence soon exceeds the reasonable scope of a species. Thereby arises a difficulty of nomenclature of a somewhat different type than is usually experienced when dealing exclusively with the recent fauna. Whenever the number of successive mutations exceeds two, the use of varietal names is apt to become impracticable. It may be impossible to allow sufficient latitude in the notion of species to include the whole series. Yet, if the evolutionary series is a particularly gradual one, as in the *episoma-mekranica* line above analysed, there is no reason why we should introduce a fresh specific name at one term of the series rather than another, although adjacent terms might be mutually regarded as varieties. For mere practical reasons, we find ourselves compelled, therefore, to bestow a different specific name on each successive term, though keeping in mind that the differences may be of a degree which, under different circumstances, might not be regarded as specific.

If the difficulties of nomenclature arising therefrom are apt to puzzle zoologists and taxonomists, they may become a source of real perplexity for certain stratigraphical enquiries. When dealing with the later Tertiary faunas, we have sometimes no other guide to their geological age than the proportion of recent mollusca which they

contain. Amongst various difficulties that have to be contended with when using this method, is that of deciding whether forms closely related to living mollusca are to be treated as varieties or regarded as separate species. This difficulty has been greatly felt in attempting to estimate the age of some of the later Tertiary marine faunas of Asia. Fortunately, with the progress of geological investigations, we are gradually becoming less dependent on the exclusive use of the percentage method. The richly fossiliferous Tertiary occurrences of the East and Far-East are gradually emerging from their isolation. As I have already noticed on previous occasions, the Tertiary fauna of Burma, now that we are becoming better acquainted with its composition, constitutes a valuable link between the Tertiary faunas respectively in Java and other islands of the Indian Archipelago on the one hand, and, on the other hand, the Tertiary faunas of western India; both groups containing a considerable number of species in common with Burma. At the same time, a closer study of the Tertiary faunas of western India has now revealed the presence of a number of identical European species. Consequently we are now able to assign definite ages to the various geological horizons in western India by direct faunistic comparison with well established horizons in the European succession, while a study of the Burmese faunas affords an intermediate relay enabling us to extend these synchronisms from Europe to Java or even to the Philippines, in spite of the fact that not a single molluscan species has been recognised as common to the later Tertiary faunas of Java and Europe.

The varietal mutations of the kind dealt with in the present paper, which are a source of perplexity in the statistical method, may become valuable auxiliaries as soon as the fossil faunas of different regions become sufficiently known to allow of a detailed comparison of their constituents. In order that these mutational varieties may become good "zone-fossils," all that is needed is that the differential characters, however slight, may be precise and of easy recognition. The smaller the degree of difference between successive mutations, the greater are the chances of each mutation being restricted to a single geological stage, as seems to be the case with some of the terms in the series *Turbinella episoma-mekranica* analysed above.

A particularly perplexing instance as regards nomenclature is that of the fossil *Melongena ponderosa* and the living *M. pugilina*. In a fauna containing *M. ponderosa*, the estimate of the proportion of living forms will differ acc ding as to whether we regard *M.*

ponderosa as a variety of the living *M. pugilina*, or as an extinct species. At the same time, this shell happens to be one of the commonest fossils in the lowest fossiliferous horizon of the Mekran beds of Baluchistan, and also in the Odeng beds of Java. The constitution of the Odeng fauna indicates a period slightly anterior to that of the Sondé series of Java of undoubtedly Pliocene age. In Baluchistan, the higher zones of the Mekran series contain a fauna closely related to that of Karikal regarded by Cossmann as Pliocene[1]. Whether we accept it or not as a variety of the living *Melongena pugilina*, the fossil *M. ponderosa*, both in Java and in the Mekran is found to characterise strata which, on independent evidence, partly faunistic, partly stratigraphical, are known to be slightly older than beds of well established Pliocene age. *Melongena ponderosa* appears therefore to be a zone-fossil characterising the upper Miocene; and the same form which, in the statistical method gives rise to some indecision, affords, on the contrary, precise evidence now that we can apply the method of regional comparison.

[1] I have formerly regarded the Karikal fauna as upper Miocene, while I referred the lower portion of the Mekran series to the middle Miocene. The detailed study of the Tertiary molluscan faunas of the East upon which I am engaged at present, has induced me to alter these conclusions. The Karikal fauna is typically Pliocene, and belongs therefore to the geological age originally assigned to it by Cossmann. The oldest fauna at present known from the Mekran beds cannot be older than newest Miocene. The bulk of the Mekran series must therefore belong to the Pliocene as was originally suggested by Blanford.

EXPLANATION OF PLATE.

PLATE 19. Diagram illustrating the evolution of certain Turbinellidæ.

RECENT FALLS OF AEROLITES IN INDIA. BY H. WALKER, A.R.C.S., F.G.S., *Assistant Superintendent and Curator, Geological Survey of India.* (With Plates 20 to 26.)

THIS short paper has been written, in accordance with the custom of the Geological Survey, with the object of placing on record known details of the falls of recent Indian Aerolites. They are four in number. All are stones and all belong to the sub-class Chondrites.

I.—THE SULTANPUR AEROLITE.

On the 10th July 1916 an aerolite fell in the neighbourhood of Sultanpur, a village in the United Provinces. Five pieces were ultimately received by the Geological Survey of India and have been registered in the collection in the Indian Museum under the name "Sultanpur" and number 274 A to E.

This meteorite, with an account of its fall, was sent by the District Officer of Ballia (G. Flowers, Esq., I.C.S.). From the reports collected by the Sub-Inspector of the Bansdih Thana it appears that the aerolite fell at about 11-0 A.M. on the 10th July 1916. Two Chaukidars from the village of Kharauni took one piece "resembling a black stone like *jhawan* (burnt brick)" and reported—"To-day at 11-0 A.M. a violent whizzing sound was heard and all village men fixed their attention toward the sky but nothing could be seen. Shortly after at a distance of one furlong from the village to the north this stone was seen coming towards the earth and falling on the field ....." The Head Constable who took the above report added—.... "It has no heat or odour."

Account of the fall.

A Chaukidar from the village of Sultanpur brought a piece of the meteorite to the station and reported—

"To-day at 11-0 A.M. a violent thundering sound was heard from the sky......and one piece of stone fell in a field to the south of the village and another in a grove......after the fall of these pieces of stones to the ground the aerial sound ceased......"

The town Chaukidar of Maniar whilst on his way to make his periodical report stated that —"When I came near Mundiari I

heard a violent thundering and whizzing sound in the sky.... until two pieces of black stones like *jhawan* fell on the outskirts of the village Mundiari and the sound ceased."

After the reports had reached the Thana at Bansdih the Sub-Inspector made enquiries and elicited further information. He states that although a whizzing sound was heard nothing was visible until "from a height of 2 *pursas* (equivalent to 9 cubits) some pieces of black stones resembling *jhawan* fell to the ground."

The fall evidently caused some consternation amongst the villagers, for the Sub-Inspector writes—"Everybody talked about this stone that a bomb had fallen and hundreds of people came to see it. The idea of a bomb having fallen was removed from their minds after they saw the stone."

From the foregoing it appears that pieces fell near three villages.

Location of the fall.

Ultimately two pieces were obtained from Sultanpur, two pieces from Mundiari and one from Kharauni.

The village of Sultanpur lies in the Ballia District of the United Provinces of Agra and Oudh in Latitude 25° 55′ 30″ and Longitude 84° 16′ 40″. Mundiari lies about 2 miles to the west of Sultanpur and Kharauni about 3 miles to the south-south-east.

General Description of the Aerolite.

The total amount of material received by the Geological Survey is 1,710·57 grammes and this weight is divided amongst the individual pieces as under :—

Piece	274	A	328·71	grammes.
„	„	B	184·70	„
„	„	C	340·55	„
„	„	D	270·05	„
„	„	E	586·56	„

Each piece shows fractured surfaces. There is very little true outer crust remaining but what is still left occurs as small patches of dull-black, slightly scoriaceous material (see the large "thumb" impression in Plate 20, fig. 1, and the small excrescence on the curved face of fig. 6). The colour of the surface, from which the outer scoriaceous crust has been removed, varies from a metallic-blue-black to a grey-black. This surface is smooth; gives the appearance of having been polished; and is studded with minute glistening specks of metal. A glance at the figures in Plates 20 and 21 reveals how divergent in shape the individual pieces are. One feature in common may be noted—each individual is well rounded

and owes its irregular shape to fractured surfaces. This is particularly evident in 274 D. This piece is, in shape, like a sector cut from a cheese. One of the fractured surfaces shows every appearance of having been smoothed by human agency (Plate 20, fig. 5, left-hand bottom corner) and leads me to suspect that the villagers made investigation of the aerolite before giving it up

The colour of the fractured surfaces is blue-black to grey-black.

Internal Appearance.

Nickel-iron in small irregular grains is very evident. Troilite is also fairly abundant. Chondri are to be seen ; some have fractured with the surface and others are unfractured. The matrix of the aerolite is medium-grained, even-textured, very tough, and the fractured surfaces, taken as a whole, are even. In fragment A there is a line of parting which is curved (see Plate 20, fig. 2). In the pieces C and E there is distinct excortication of the outer layers.

Specific Gravity.

The specific gravity of each individual piece has been taken by immersing it in water. The following results were obtained :—

Piece 274 A	sp. gr.	3·55
" " B	" "	3·5
" " C	" "	3·52
" " D	" "	3·51
" " E	" "	3·52

Microscopic characters.

In thin sections under the microscope this aerolite is seen to possess considerable variation in texture. In the part illustrated by Plate 21, fig. 2, a large chondrus of enstatite with radiating fibres occurs. Individual crystals of olivine are set in a much finer ground-mass. This difference in size between the olivine crystals and the ground-mass is not nearly so marked in other sections. The black patches in the illustration mainly represent nickel-iron. Troilite is found most commonly in small grains in close proximity to nickel-iron, but occasionally it occurs in nests which in size approximate to the smaller pieces of the iron. Throughout the aerolite there is black material which occurs interstitially. It has not been determined.

Classification.

I have compared this aerolite with those in the collection of the Geological Survey of India and I find that it is most nearly comparable to the McKinney fall. I propose, therefore, to place the Sultanpur Aerolite in the class : Stone, No. 26, Black Chondrite, Cs of Brezina.

II.—THE RAMPURHAT AEROLITE.

The meteorite which has received this name fell in Bouripara, Rampurhat town, on the morning of the 21st November 1916. Its registered number in the collection of the Geological Survey of India is 275.

Account of the fall.

It was received by this department through the prompt action of Mr. Haywood, Superintendent of Police, Birbhum District, who at the same time forwarded his Inspector's report of the circumstances of the fall. The report reads as follows :—

"I........report that an extraordinary phenomenon took place this morning at about 9-30 A.M. at Bouripara, Rampurhat town. A stone of about 12 tola in weight was seen falling from above preceded by a roaring sound like that of an earthquake which continued for about 2 minutes and travelled a great distance. The direction from which the sound came could not be ascertained. The stone was quite hot when it fell down and emitted a smell of gunpowder. It created a cavity on the ground of about an inch depth and one inch and a half in circumference."

Location of the fall.

The town of Rampurhat, in the Birbhum District of Bengal, lies in latitude 24° 10′ and longitude 87° 46′. It is a station on the East Indian Railway Loop Line.

General Description of the Aerolite.

This aerolite is an almost perfect specimen with no entirely unfused portion visible. Partially fused matrix is to be seen in three places which are depicted in Plate 22—in fig. 1 the top right-hand corner and bottom point, and in fig. 2 the depression at the top right-hand, are the places.

The weight of the aerolite as received by the Survey was 99·93 grammes.

To the eye the crust is smooth and finely granular. In colour it varies from grey-black to brownish-black. There are a number of small shining pimples of fused material. Under a lens the crust is seen to be scoriaceous ; very fine in texture in some parts and more coarse in others. All parts of the crust when viewed under a lens glisten. Faint reticulate cracks are to be seen.

I think the best idea of the shape of this aerolite is conveyed by describing it as a distorted tetrahedron. In the report of the fall it is stated that the aerolite buried itself in the soil. When

the meteorite reached the Geological Survey an earth-mark still adhered to the most acute angle (bottom of fig. I, Plate 22) and I presume from this that this was the forward portion during flight. On the crust there is no undoubted flow structure.

Specific Gravity.

The specific gravity of the aerolite is 3·579. When removed from the water and partially dried the crust was a greyish-brown, mottled colour and showed a large development of reticulate cracks.[1] The crust resumed its normal appearance when it had dried.

Classification.

No opportunity of cutting this aerolite, and so enabling one to see the internal structure, has occurred. At what I take to be the forward end of the aerolite there are signs of chondrules. I can only express the opinion that this meteorite is a stony chondrite.

III.—THE RANCHAPAR AEROLITE.

The pieces which represent this meteorite were obtained through the initiative of the Sub-Divisional Officer, Jamtara (C. N. De, Esq., M.A., B.L.), who acted on the report of the Sardar of Kundahit Circle. Finally the aerolite was sent to the Geological Survey by the Deputy Commissioner of the Santhal Pargannas and is now in the collection of the Geological Survey under registered No. 276.

Account of the fall.

Mr. De writes—"....that the Sardar of Kundahit Circle reports that on the 20th February last (1917) between 8 and 9 A.M. the fall of a meteor was witnessed by the villagers of Ranchapar and Deoli in Taluk Babu Pur and that its fragments were picked up by those villagers." Further enquiries were made by the Sub-Divisional Officer with the object of obtaining first-hand accounts and from these enquiries "......it appears that they heard a sound which was followed by rising of dust and on their going up to the place saw the meteorite ; they also allege that the meteor fell between 7 and 8 A.M."

Location of the fall.

Ranchapar is not shown on sheet No. 236 of the Bengal Survey, scale 1″=1 mile, but Deoli is shown at latitude 23° 58′, longitude 87° 6′ on the same sheet. There are, however, two villages named Deoli about a mile and a half apart. The Deputy Commissioner of the Santhal

[1] Rec., Geol. Surv. Ind., Vol. XLVII, p. 275 (1916).

Pargannas has supplied the information that Deoli and Ranchapar bear the settlement Nos. 5 and 10 respectively in the Kundahit Circle of the Jamtara Sub-Division and further, that both lie alongside the Kundahit-Fatepur road and that Ranchapar is about a mile to the north-west of Deoli.

General description of the Aerolite.

Three pieces of the aerolite, now numbered 276A to C were picked up by the villagers of Ranchapar. These pieces weighed, when received, 148·82, 140·31, and 0·29 grammes respectively. One fragment, 276D, weighing 77·85 grammes was obtained by the villagers of Deoli.

Fragment 276A is the remains of a rounded mass of indeterminate shape. The general outline and the irregular distribution of the crust are shown in Plate 22, fig. 4. A concave, crust-covered surface with fairly large pieces of unfused nickel-iron is seen in fig. 5. This surface also shows indications of "thumb" marks. Another piece of nickel-iron is shown in the left of fig. 4. The crust is black with reddish-black patches. Under a lens it is scoriaceous and is studded with minute glistening specks.

No. 276B has the appearance of having been detached from a tabular mass. It has one large fractured face and a large portion of one corner devoid of crust. The crust is smooth but under a lens is seen to be finely scoriaceous. In colour it is glistening black with patches of grey and red.

No. 276D appears to be a small portion detached from a tabular mass similar to 276B. In colour it is much blacker and, in parts, the surface is much rougher. If I may use non-scientific words, it appears burnt with a distinct cinder-like look in patches.

Internal appearance.

When these fragments of the meteorite were received by the Geological Survey they were medium grey in colour. But now, although they have been sealed up, they are dark grey. The matrix is tough in texture, medium in grain and the fractured surfaces are fairly even. Chondri, lighter in colour than the matrix and breaking with it, are to be seen. Some of these attain a diameter of 3 millimetres. A considerable number of chondrules are only one millimetre in diameter. In addition to the large patches of nickel-iron already referred to, the matrix of the aerolite is evenly permeated with small grains of the alloy. Troilite also is abundant, and one nest of this mineral, which attains a diameter of 4 millimetres, is to be seen in piece A.

Fragment 276D show a thin black vein.

Specific gravity. The specific gravity of the pieces is as under :—

276 A	sp. gr.	3·72
276 B	„ „	3·76
276 D	„ „	3·73

Microscopic characters. From an examination of a thin slice of this aerolite under the microscope it is found to be of medium grain and very largely composed of olivine. Chondri and chondrules are both present and both appear to consist in some cases of olivine and in others of enstatite. Nickel-iron is scattered in irregularly shaped grains throughout the stone and troilite in nests is similarly disposed. By reflected light it is seen that the proportion of nickel-iron to troilite is approximately as 4:1.

Classification. After comparison I have concluded that this aerolite is most nearly of the type of the Bishnupur and Farmington falls. I therefore place it, tentatively, as to pieces A and B into class : Stone, No. 26, Black Chondrite, Cs ; and as to piece D into Stone, No. 27, Veined Black Chondrite, Csa.

IV.—THE CRANGANORE AEROLITE.

The first information of this aerolite, which fell at Cranganore on the 3rd July 1917, was received from Captain C. W. Shearme, R.I.M., Port Officer, Madras, who forwarded one fragment (No. 277A) to the Geological Survey for examination. This fragment had been obtained by the Port Officer, Cochin, from the Dewan of Cochin. As the result of further inquiries through the Port Officer, Madras, four more pieces were obtained.

Through the interest of the Resident in Cochin the largest fragment of all (No. 277G weighing 713·36 grammes) was generously given to the Geological Survey by the Cochin Darbar.

This aerolite has been incorporated in the collection of the Geological Survey of India under the registered number 277. The total weight of material received was 1460·24 grammes distributed as under :—

Piece	277	A	445·30	grammes.
„	„	B	29·14	„
„	„	C	10·22	„
„	„	D	5·52	„
Dust	„	E	0·90	„
Piece	„	F	255·89	„
„	„	G	713·36	„

Account of the fall.

The Port Officer, Cochin, in making his original report to the Port Officer, Madras, wrote " .... the explosion referred to .... is said to have occurred in the vicinity of Cranganore at the mouth of the Palliport river, 14 miles north of Cochin, where fragments of what is believed to be a meteorite fell to the earth and were picked up by some people." The Port Officer continued—" The explosion occurred at 12-45 P.M. on the 3rd instant whilst I was sitting at breakfast, and resembled the report of a heavy gun followed by a roar of about four seconds duration. It was heard as far south as the Vembanad Lake or a total distance of about 35 miles. The weather was unusually fine, with a cloudless sky and a steady moderate breeze from the N. N. W." The Port Officer also sent reports from the Superintendent of Police, Cochin State, and from the Sub-Inspector of Cranganore, and from the first of these I transcribe—" First of all, the people on the Kara Sea Coast heard some sound like the report of a petard which was followed by resonance like that of a railway train passing over a bridge or, as some say, of a *jutka* going at breakneck speed over a rough metalled road. Some say that the report was heard from the south-west (in the sea) and travelled north-east. Others thought that the first report was from the north-west and it moved south-east. So it will be seen that there was no difference of opinion that it was heard from the west and that out in the sea."

" Synchronous with the report and the approaching resonance was the fall....in several places on the beach and in the interior." From the Sub-Inspector's report—" The first three sounds (like that of pop-guns) are said to be heard one closely followed by another. Not less than six pieces have fallen, but most of them were cut to pieces when found out. The area ranged from Eriyad to Kara and Madavana, *i.e.*, within a radius of nearly three miles. The distance from the beach to the eastern-most is nearly 3½ miles, *i.e.*, one fallen in Madavana. The marks left by the fall on the earth though meddled by the neighbours all have a more or less vertical direction and the pits are about a span deep. A small piece, when analysed, is found to contain iron, sulphur and silicon."

Location of the fall.

Cranganore lies in latitude 10° 11′ 30″ and longtitude 76° 16′ 30″. It is shown on sheet No. $58\frac{B}{4}$, scale 1″= 1 mile, of the Madras Survey. Cranganore is in Cochin State.

General description of the Aerolite.

Fragment 277A, shown on Plate 24, is of an irregular polygonal shape. By far the major portion of the surface is covered with crust. This crust is shining black with numerous small reddish-brown patches. Taken on the whole the surface is smooth but there are numerous small black shining papillae of fused material and a fair development of reticulate cracks. Two surfaces show shallow "thumb" marks (figs.—2 & 3) and on one (fig. 2) there are distinct signs of flow in the fused material.

The crust of fragment 277B (see Plate 24, fig. 1) is of a similar type to that of 277A but it is almost entirely covered by small "thumb" pits with an average diameter of 4 millimetres.

From the figures of fragment 277F shown on Plate 24 it will be seen that it is roughly cube-like in shape with one face and two small corners devoid of crust. The surface is a dull, reddish-black to shining black. It is smooth, cracked in parts, and has a number of minute shining lumps of fused material disposed over it.

An irregular octahedron is the shape of fragment 277G (Plate 25). From one face and from a small corner the crust has been removed. The colour of the crust is black. It is dull of lustre and has irregular, dark red-brown spots and patches. The surface is fairly smooth but there is a small amount of reticulate cracking. The top faces shown in figs. 1 and 2, of which fig. 3 is a plan, are, in my opinion, the forward faces during the flight of this fragment. They are smooth-crusted with numerous small, fused and glistening patches.

Those faces in figs. 1 and 2 which show marked "thumb" impressions I regard as the rearmost faces during flight.

Internal structure.

These are two distinct types of matrix in this aerolite. Fragments B, C, D, G, belong to the type medium in grain, blue-grey in colour, and easily affected by the atmosphere. The matrix of this type is fairly friable in texture. Chondri are scarce. Nickel-iron is dispersed throughout the mass in small, irregular, gleaming grains. A certain amount of troilite in minute grains is also to be detected.

The second type, represented by 277A and F, has a matrix which is also blue-grey in colour but is slightly finer in grain and less friable than the other. It is also more resistant to the atmosphere, and, so far has shown very little iron-staining. A few chondri are visible. Nickel-iron and troilite in minute grains and

small patches are disposed throughout the matrix. The outstanding feature of this type is that there are a few very thin black veins.

Previous workers on meteorites have observed this difference of type in individuals of one fall. The Dokachi aerolite may be quoted as an example[1].

Specific gravity.

I took the specific gravity of one specimen of each type with the following results :—

No.	277 F .	sp. gr.	3·521
„	277 G .	„	3·472

In both cases, as I have previously noted with other aerolites, these specimens when half-dry exhibited a greyish crust, mottled and cracked in a reticulate fashion but more pronounced in F than in G.

Classification.

I consider that fragments B, C, D, G, may be referred to the class : Stone, No. 15, White Chondrite, Cw, of Brezina and that pieces A and F may be regarded as Stone, No. 16, Veined White Chondrite, Cwa.

EXPLANATION OF PLATES.

PLATE 20, Sultanpur Aerolite.

Figs. 1 and 2, portion A ; fig. 3, portion B ; fig. 4, portion C ; figs. 5 and 6, portion D.

PLATE 21, Sultanpur Aerolite.

Figs. 1, portion E ; fig. 2, photomicrograph of a part of the aerolite. ×20

PLATE 22, Rampurhat and Ranchapar Aerolites.

Figs. 1 to 3, Rampurhat Aerolite ; figs. 4 to 6, portions A and D ot the Ranchapar Aerolite.

PLATE 23, Ranchapar Aerolite.

Figs. 1 and 2. portion B ; fig. 3, fragment C ; fig. 4, photomicrograph of a part of the aerolite. ×20.

PLATE 24, Cranganore Aerolite.

Figs. 1, 2 and 3, portion A.

PLATE 25, Cranganore Aerolite.

Fig. 1, fragments B, C and D ; figs. 2, 3 and 4, portion F.

PLATE 26, Cranganore Aerolite.

Figs. 1, 2 and 3, portion G.

[1] *Rec., Geol. Surv. Ind.*, Vol. XXXV, Pt. I, pp. 68-77 [1907].

GEOLOGY OF A PART OF THE KHASI AND JAINTIA HILLS, ASSAM. BY THE LATE CAPTAIN R. W. PALMER, M.C., M.SC. (MANCH.), F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plate 27.)[1]

INTRODUCTION AND PHYSICAL FEATURES.

THE Khasi and Jaintia Hills form part of the south-western plateau region of Assam. They lie roughly between latitudes 25° and 26° N. and longitudes 91° and 92° E. To the north Kamrup separates them from the Brahmaputra valley, to the west lie the Garo Hills, to the south is Sylhet and to the east are Nowgong and Cachar.

Almost precisely in the centre of the area lies Shillong, the capital of Assam, and 30 miles due south of it is Cherrapunji, the old capital, lying on the direct route between Sylhet and Shillong. The Shillong-Cherrapunji area was examined by T. Oldham (*Mem. Geol. Surv. Ind.*, Vol. I, pp. 99-207, 1859) and mapped in detail by H. B. Medlicott (*Mem. Geol. Surv. Ind.*, Vol. VII, pp. 151-207, 1869). Apart from these two papers the publications dealing with the Khasi Hills refer to the coal occurrences, and give only such stratigraphical details as were sporadically collected with a view to the understanding of the coal.

A good deal of unpublished work has, however, been done in the area by officers of the Geological Survey of India. This work left only three untouched areas and it is one of these with which I dealt in the season 1920-21. Its northern boundary runs a few miles south of the road running west from Mawflang *viâ* Nongstoin to the Garo Hills. Its westward boundary is approximately the line of the Kynshiang River. The eastern boundary runs from Mawrongor to Mar Shillong: from there it runs east to Rangsohkham and then southward to the plains four miles west of Shella. The southern boundary is almost exactly the northern boundary of Sylhet, which follows the marked change in geographical features where the hills rise from the alluvium of the plains.

[1] This paper was submitted for publication by its author just before his resignation and death. He therefore had no opportunity of confirming his opinions or revising the proof. I have thought it best to reproduce the paper as it stood and to limit emendation to the minimum possible. EDITOR.

The area covers slightly more than 600 square miles and the work must be regarded rather as preliminary than final. The policy adopted was to complete a general map of the whole district in one season. This entailed moving fast and did not permit of covering the ground more than once, so that several problems have been left unsolved.

The area is one of the wildest in the whole region. In the north it is a rolling plateau some 5,000 feet above sea-level, supporting little but coarse grass. The plateau in the western area slopes throughout steadily to the south-west. Elsewhere the high land slopes very gently to the south and then plunges suddenly from a height of 4,000 feet to the plains, which are less than 50 feet above sea-level. There are foot-hills in the east, but these are inconspicuous from the south, and the traveller on the plains sees the hills rise before him like the wall of a mighty fort. The wall, however, is a broken one. The district boasts of the highest rainfall in the world, and the plateau and its southern face are extremely deeply trenched by narrow valleys. The rivers flow in impassable gorges from two to four thousand feet deep, and but a mile or two across at the top; between them, bidding vain defiance to the elements, rise, like so many giant castles, the flat-topped remnants of the old plateau. There are three main rivers, the Kynshiang, the Rilang and the Umngi.

The Kynshiang rises near Mairang in the north and is known in its upper parts as the Um Kynshi. It pursues a south-westerly course till it enters the area under description near Mawrongor. It then turns westward, following an abruptly zig-zag course till, in the centre of Nongstoin territory, it turns south and sweeps in a broken semicircular curve to the plains. Its tributaries drain the whole of the north-western part of the area. The Um Rilang rises near Mairang and flows to the south-west in an ever deepening gorge till it joins the Kynshiang at Rilang Bazar; its gathering ground is a strip some 6 or 8 miles wide crossing the area mapped from the north-east to the south-west. The Umngi also rises near Mairang and runs in a course roughly parallel to that of the Rilang; it reaches the plains through a gorge at Tanglah. The only other rivers in the area are those of the southern face of the plateau. These are small, for the larger rivers trenching the plateau only permit of their receiving water from a restricted area. They flow due south down the hills and, following a circuitous course over the plains, find their way, in common with the three larger rivers, to the Surma in Sylhet.

Means of communication in this region are clearly bad. No paths passable by mules traverse it. Only in the north can transport animals be used, and even there the gorges are so often impassable that beasts of burden would be of very limited use. They are not found in the district, all porterage being done by men and women who carry burdens on the back supported by a plaited cane rope passing round the forehead.

There is a large trade in dried fish, which is caught in Sylhet and marketed at Rilang and Lengar Bazars on the banks of the Jadukata. The vendors from the hills carry the fish from Lengar *viâ* Nongktieh and Rangthong to Mawkyrwat market, where it is sold to people from Shillong. This route is the most important in the district, and could be made into a useful artery but for its passing of necessity over a great gap between Rangthong and Nongktieh. Here the tributaries of the Rilang and Umngi have cut back through the watershed dividing their valleys, and the path descends by rough and steep stone steps for a thousand feet and then rises nearly to its old level. Another disadvantage to this route, too, is that it ends on the Jadukata River and from Lengar the journey to the plains must be made by boat. The route northwards from Rilang is too precipitous at first and placed too far to the west to afford a ready means of access to the plains.

About fifteen years ago a road trace was cut from Mawflang *viâ* Mawsynram and Mawpat to Kathalbari (Bhawalgaon) on the Umngi. Later it was proposed to alter the alignment of the road in the south and to bring it to the plains near Tanglah. This general route is the only practicable line for a cart-road from Shillong to Lengar Bazar. Until it is constructed a very large percentage of the Khasi labour must be employed in porterage.

The people who inhabit this wild land are a primitive folk of supposed Mongolian origin. They are frank and outspoken, intensely proud, intolerant of authority and quick to take offence. They have a keen sense of humour and the hilarious, noisy coolies contrast strangely with the usual dull porters of India. Though there are many converts to Christianity among the Khasis, the majority of them are animists or spirit worshippers, and amongst them the traveller may be dependent, for his supply of coolies and the food that is obtainable, on such auguries as may be read in the spasmodic movements of the intestines of a disembowelled fowl.

The Khasi language is an isolated type which the Welsh missioners have recently reduced to script. The people are divided into a large number of totally distinct tribes ruled by kings or *siems* who are not hereditary but elected by and from certain leading families.

The distribution of vegetation may be briefly referred to. The plateau and the isolated flat-topped hills support for the most part only coarse grass, but dense jungle occupies all the valley slopes and the plateau edge. Some of these slopes are living herbaria, and show a wonderful succession of different floras from the tropical growths near the rivers to the temperate plants on the plateau. In a short but difficult climb perhaps only a mile long one may often encounter a remarkably varied flora, but on the whole the tropical elements seem to master the temperate, and, extending far above their natural elevation, beat their less prolific neighbours in the hard struggle for existence.

The plateaus are often formed of different rocks from those of the valley slopes, but the distribution of vegetation is more dependent on the topography than on the structure of the district. This fact is clearly seen in the western part of the area where the land slopes steadily to the south-west. Here even the plateau is covered with dense bamboo jungle, encouraged, no doubt, by its exposure to the rainy south-west winds and by its comparative protection from the cold northerly gales.

The geology of the district, however, does to some extent affect the vegetation, for in the south the country underlain by crystalline rocks is almost invariably more thickly clothed with jungle than that underlain by the nearly horizontal Cretaceous. The reason for this is not due to any chemical property of the rocks, since the composition of the crystallines is very similar to that of the felspathic Cretaceous sandstones, but is to be sought in the structure. The gneiss has its bands exposed in section, which leaves it readily open to the attack of the elements, while the Cretaceous rocks present only the surface of their bedding planes to the weather. Further, as will be shown later, the crystallines were in places weathered before the Cretaceous was deposited on them, and hence have been exposed to disintegration for a longer period than the sedimentary series. For these reasons the gneiss or granite has usually a thicker soil cap on it than the Cretaceous sandstones, and on the thickness of the soil largely depends the distribution of vegetation.

The chief crops grown in the area are potatoes and rice in the northern plateau, and oranges, *pan* and *tezpata* on the southern slopes. The biggest crops of potatoes and rice come from Maharam and Nobosophoh, in which the weathered granite is used freely for the construction of paddy fields in the valleys. On the valley slopes jungle is burned, and the soil, fertilised by wood ash, serves for a single season for the cultivation of a coarse millet and the tree potato.

The general description of the area has already occupied more space than it is usually assigned in a geological report, but in this area the form of the country is so bound up with its structure, and so limits and controls the destiny of its people, that I have ventured to allot a large amount of space to the general subject.

There still remain two striking physical features of the country which I have not yet discussed, and these require a geological explanation. The first is a feature obvious on a glance at the map, but one which is more striking the more the map is examined and quite astounding in the country itself.

I refer to the remarkable straightness of the river valleys of the plateau area. The main rivers and their tributaries run typically in zig-zag, angular courses each reach of which approximates closely to a straight line. There are, of course, winding valleys but these are the exception instead of being the rule. The river Kynshi in the northern part of the area runs in many straight reaches, but the straight valleys are best developed in the central part of the area and especially by the tributaries of the Rilang river. These descend from the local watersheds in straight lines, and, typically, the opposing stream, descending from the other side of the watershed, runs in the same line. There are many cases of this, but three instances will suffice to illustrate the point. The Um Saurata rises 1½ miles north-east of Rangthong. It runs in a gently winding course on the uplands for half a mile, then turns south-south-east, and for four miles flows in a valley which deviates but slightly from a straight line. At the top of this straight reach is a very narrow water-parting, and from the north of it, flowing to the Rilang, runs a stream for more than a mile, in a course exactly in line with that of the upper waters of the Um Saurata. The water-parting between the streams is a mere bank about 20 yards wide, and an observer standing on it cannot fail to be struck by the extraordinary form of the two valleys. He seems to be standing on a bridge spanning a great cutting, still under

construction, and which has been cut deeper and deeper as it recedes from him.

The same effect is seen a mile north of Umdohlup in Nobosophoh, where tributaries of the Rilang and Kynshi arise close together and flow in one line in directly opposite directions. Perhaps the most striking instance to the traveller, though not to the map student, is seen just south of hill "5230," west of Phudtde in Maharam. From here a large stream flows north-west to the Kynshi and a small one south-east to the Rilang. The upper waters of the larger stream are exactly in line with the smaller one. Below, the tributary of the Kynshi bends slightly to the north, yet its course remains straight enough to demand explanation, and is continued on the other side of the Kynshi by a slightly curved tributary some two-and-a-half miles long. The general line of these streams is also continued south of the Rilang, for a river known as the Phud Langdew joins the Rilang nearly opposite to the point where that river receives the waters of the stream flowing south-west from hill "5230." The last mile of this river lies in the line of the streams described. There are here 11½ miles of straight river valleys, which lie along a slightly bent line and of which the mutual connection cannot be doubted.

This third instance of a general feature in the district is the largest and most striking. It is, too, the only instance in which I was able definitely to trace the origin of such a straight valley by observation on the spot. Even here I only succeeded in being able to detect the origin of the straightness over the southern portion of the line. From near the point "4648" in the valley of the Um Shyrap to the sudden bend in the Phud Langdew north-east of Phudja-ut-Rang-thong the line of straight valley marks a fault line. To the north of the river is a coarse pink granite, to the south a fine banded gneiss. The contrast between the north, with its bold granite tors and occasional clumps of trees, and the south, with its rolling, barren, open moorland, is strongly marked. Nowhere does either rock type cross the river. The junction cannot be one of normal contact. There can be no reasonable doubt that it is a fault and that the rivers owe their straight course to erosion along the fault plane.

In the north this system of valleys does not follow the gneiss-granite junction but the right to suggest that they follow the same line of fault cannot be denied. If we assume the fault to continue with diminished downthrow in the north, so that granite occurs

on both sides of it, we find a ready explanation of the straightness of the tributaries of the Kynshi running in the granite area.

That the cause of the straightness of the valleys in this particular case is a general explanation of the straight valleys in the Khasi Hills is not an unreasonable generalization. We know that the area was much disturbed in pre-Cretaceous times; that it is a fragment of peninsular India trapped between the Himalayan and the Burmese elevations; that it is a region of frequent earthquakes; that it no doubt has an extensive system of faults; and that rivers are ever ready to make light of their task and cut their channels along lines of weakness.

There is, however, another explanation which may account for the straight valleys. It certainly explains the origin of a few shallow ones, and from these a plausible series of graduations can be made out leading to the largest in the area. I believe the explanation already given deals with the chief forces in operation, but I am compelled to attribute some valleys to the causes about to be explained. To discuss the question here it is necessary to anticipate a later part of this paper and describe briefly the geology of the plateau.

The plateau is built of gneiss and granite and is freely scattered with approximately horizontal outliers of Cretaceous sandstone. These outliers occur all over the area and to the north of it. They are the remnants of a formerly continuous sheet, of which quite large areas are preserved in the south. This sheet of sedimentary rocks is undisturbed and is not broken by faulting to any appreciable extent, and yet the rivers which run solely in it flow like the rivers of the gneiss and granite country, typically in a succession of straight reaches. The straightness of the valleys in the Cretaceous country is not so obvious as in the granite country, because the former rocks cover a much smaller area, but instances may be seen on the map at Mawsynram, Nontynger and Lum Kohkhlam, and on a small scale can be detected all over the district. Their explanation, fortunately, is obvious; they are due to running water cutting and widening the joint planes in the sandstone. Streams, thus started, rapidly cut their way through the thin Cretaceous rocks and erode a bed below in the underlying crystallines, along a course that has been determined solely by the run of the joint planes in the Cretaceous. This stage is represented, I suggest, by valleys south of Rangthong, north-west of Phlangmawphra and south of Nonglang. In these and

many other places there are straight steep-sided valleys with their flanks built of Cretaceous sandstones, and their beds cut in crystallines. Unfortunately I was not in any instance able definitely to trace the origin of such a valley to a joint plane, but the suggestion affords a ready and, I believe, the only reasonable explanation of its origin. It is clear that such a valley, once it has its course definitely determined in the underlying gneiss, will continue to cut its bed along that line, after all traces of the overlying Cretaceous have been removed by denudation, and when the causes which determined its remarkable course are no longer apparent. Such may be the origin of some of the straight river valleys in the crystalline area of the Khasi Hills.

The origin of the exceptionally narrow and deep valleys or cañons that intersect the plateau, provides only a small problem for the scientific mind, but it very obviously puzzles the intelligent members of the Khasi community and the Europeans who visit that area. They stand amazed on the edge of some mighty cliff and reflect on the forces of nature which have carried the rushing stream some three or even four thousand feet below them. They note the falls at the ends of hanging valleys which plunge their waters into the main valley down sheer cliffs 500 feet to 1,000 feet high on to the talus slopes below. Across the valley and seemingly but a stone's throw away, the flat grass-land on which they stand is continued. The flatness and peace of the uplands contrast strangely with the terror of the gorges, and the whole scene invites, nay compels, speculation. Such chasms are rare and the unscientific observer looks for their origin in rare phenomena. The Khasi plateau is a seismic area. Earthquakes are frequent and the memory of the destructive shock in 1897 dies hard. What more natural than to attribute the gigantic river gorges to these little-understood phenomena? The chasms are rifts in the earth's crust produced by earthquake shocks; such is the popular opinion. This explanation is completely wrong. The gorges have originated, as have the smallest valleys of the uplands by the erosion of the rivers which now flow in them. Their exceptional depth and width they owe to two local features of the district. The first of these is the steepness of the southern face of the plateau, which, by giving the drainage waters a very high velocity, enormously increases their powers to cut down and back into the land. The second is the very high rainfall of the area. Eight hundred inches of rain a year have been recorded in Cherrapunji, 600 inches

is not uncommon, and the average is more than 400. This rainfall is concentrated mostly within a period of four months.

The rate of erosion of a river-bed depends on the velocity and volume of its waters. The amount and concentration of the rainfall in the southern Khasi Hills gives the rivers an almost cataclysmic action. The steep slope of their courses and the volume and speed of their waters concentrate their efforts on the erosion of their beds. They have little opportunity to erode their banks and so widen their valleys. The straightness of their courses is a minor factor in the rapid down-cutting, for erosion of banks is negligible except at the bends of a river valley.

As the erosive action of the rivers progresses their beds will eventually attain a gradient at which erosion will be impossible and all the efforts of the waters will be spent on eroding the valley sides. The hills will melt away. Needless to say the low gradient essential for this process will be attained first in the lower waters of the rivers. The Jadukata is already in this condition and so is the Umngi near Tanglah. The Rilang river where it joins the Jadukata may not have fully attained this condition but approximates to it, and its destructive action is more in the erosion of its banks than in that of its bed.

While the rivers of the area in the plateau region have been mostly employed in cutting down their beds, their valleys have been slowly widening owing to the sub-aerial denudation of their flanks and to landslips from the unstable cliffs. It is by starting such landslips that earthquakes have produced their greatest effect on the scenery. The unstable sides of the gorges naturally tend to fall into the valleys during an earthquake, so that the general effect of seismic waves in the Khasi Hills is to widen and fill in the deep and narrow valleys—in fact to destroy the peculiarities of the remarkable topography of which they are popularly held to be the originators.

Even as agents in the production of landslips earthquakes have done little in the Khasi Hills. An earthquake is not of itself the cause of a landslip. It is the trigger which sets an unstable mass moving. The instability of the mass is due to other forces, and these, in the plateau area are the down-cutting streams. It is fashionable among the Khasis to attribute every landslip and every feature of landscape of a somewhat abnormal character to earthquakes, but I gained a strong impression that the effects produced on the scenery even by the 1897 shock were very small. A few fissures opened, a

few joint planes widened, and many, but only very local, landslips were started. The 1897 shock too was of exceptional strength, for the old Khasi monoliths are reported to have been standing prior to that date.

I have considered it necessary to digress at such a length on the effect of earthquakes in the area because the mistaken popular opinion on the subject may easily affect the district adversely. As an instance of this I was told on good authority that a coal-mining expert reported unfavourably on the prospects of working coal in the Khasi Hills, on the grounds that earthquakes had broken up the seams and rendered them unworkable. There is no justification for such a statement.

GEOLOGY.

In the area examined the following rock systems are developed :—

Alluvium.
Post-Nummulitic sands and clays.
Nummulitic limestones.
Cretaceous sandstones.
Sylhet trap.
Granite.
Gneiss.

I will describe these series individually later, but before doing so will deal briefly with their general relations to one another, and indicate the main structural features of the area.

The plateau is an ancient mass of gneiss much intruded by a coarse granite. To the south the Crystalline series is replaced by a great mass of lavas which were named by Medlicott in the Cherrapunji area the Sylhet Trap. The relations between the gneiss and the trap will be discussed later, as they are somewhat obscure, but the two series at one time formed a land area which in the Cretaceous age was slowly overspread by an encroachment of the sea from the south. On the sloping sea-bed, a carpet of Cretaceous, Nummulitic, and later Tertiary rocks was laid down. These sedimentary rocks all thicken to the south and thin out to the north. The three formations are differently distributed but are quite conformable one to another. Along the southern edge of the plateau the rocks have been bent down in a monocline to the south and sink beneath the alluvium of the plains. The southern edge of the plateau is a dip slope. This

general structure of the district is illustrated in the section shown in Plate 27 which runs from the plains of Sylhet near Rangpur northwards to Lum Nongsynrih in Maharam.

The Gneiss.

The gneiss occupies the greater part of the district and underlies the Cretaceous in the north and the Sylhet trap in the south. Though much intruded, it is itself remarkably uniform. It is light grey in colour, fine in texture and distinctly banded. The major part of the rock consists of granular felspar and quartz. The orthoclase is usually in the form of microcline and a certain amount of plagioclase is typical. Magnetite is always strongly developed and hornblende and biotite are the ferro-magnesian minerals. Small granules of apatite are sometimes found.

Typically the rock face shows a light grey matrix with very thin black bands running parallel to one another and not much more than $\frac{1}{8}$th inch apart. In these black bands the dark minerals are concentrated, while the light bands, owing to their fine granular structure, superficially resemble felspathic sandstones. Under the microscope between crossed Nicols the quartz and felspars frequently show strain shadows, and in the complete absence of any flow structures, it is suggested that the origin of the gneiss is due to pressure rather than to heat, and to the folding of a solid rather than of a molten rock. The freshness of some of the felspars suggests they may be secondary, but typically they are much altered, and frequently they show a peculiar striation due, apparently, to the secondary development of muscovite along their cleavage faces.

In the southern gneissic area, in the valleys of the Rilang and Umngi, the ferro-magnesian element is subordinate, and the rock consists almost entirely of quartz, felspar and magnetite. It may be that the magnetite is an alteration product of the hornblende or biotite, but it has not always this appearance, and the rock strongly suggests an aplitic granulite.

In the eastern area the valley of the Umngi is largely built of a different type of gneiss. Round Nongmanat the gneiss contains much muscovite, and in places might fairly be described as a mica schist, while four miles to the west, on the path above Nongkynbah, an amphibolite is seen. This last is composed of broad, black and light grey bands. The dark foliæ consist almost entirely of fresh

green hornblende with a very small amount of plagioclase. The light bands are made up of felspars, quartz and hornblende. The more basic bands may possibly originate from a dolerite or other pyroxene-bearing intrusive, but it is impossible to make out the relations of the rocks on this valley side, owing to the amount of scree material and the dense bamboo jungle, which make the extremely steep slope quite impassable over large areas, and conceal its geology in the parts where it can be traversed.

In the neighbourhood of Wahkaji some large slabs of broken dark mica were seen. These are quite exceptional however, and the gneiss is typically a fine granulite with no large or conspicuous elements in it.

As might be expected, the gneiss is much intruded. The granite, to be dealt with shortly, forms the major part of these intrusions, but there are also more basic dykes of which fragments are seen in the soil *débris*, but only in one locality did I succeed in finding them *in situ*. In the valley of the Umngi one mile north of Raibah, on the track to Nongnam, in the bed of a tributary stream, a dolerite dyke, about 20 yards wide, cuts through the gneiss with a bearing 10° S. of W. to 10° N. of E., and from this point northwards to the river two or three other small dykes of a similar nature are exposed. None of them can be followed for any distance.

The gneiss is foliated for the most part in very flat planes, but locally the foliæ may be strongly contorted. The foliation runs typically east and west over the whole area, so that it would appear that the dynamic forces which induced it acted from either the north or south.

The gneiss area formed a land mass in pre-Cretaceous times, and its old land surface has in parts been dissected from the overlying rocks and is again being exposed to denudation, but it will be best to discuss this question later.

The Granite.

The distribution of the granite is very difficult to follow, for it is very irregularly intruded into the gneiss in countless veins and bosses. Igneous rocks are rarely exposed *in situ* on the plateau, and the river-beds are usually impassable except for short distances. For this reason I have not attempted to mark the smaller granite areas on the map, and have only very approximately indicated the boundaries of the main north-eastern granite area. The granite

is probably little younger than the gneiss, and to the south below Mawsynram passes, itself, into a strongly banded coarse gneiss apposed to the fine gneiss already described.

In the north the granite is a structureless aggregation of large porphyritic pink orthoclase, quartz and biotite. A little plagioclase is usually seen, and quite large crystals of magnetite are typically developed. Sometimes by a reduction in the amount of quartz the rock approaches a syenite, and in two large areas in the neighbourhood of Nonglwai in Nongstoin and Mawthawpdah in Maharam the phenocrysts of pink felspar are replaced by small crystals of white orthoclase, and the biotite becomes more dominant. This grey granite seems merely a variety of the pink. There is no evidence to show that it is a separate intrusive mass.

Following the structureless pink granite from the north southwards, the felspars begin to show a tendency to align themselves in definite planes with their longer axes parallel to one another, and this feature, which at first seems the casual tendency that is so commonly met with in many unfolded granite masses, can be traced to pass to the south into the folded structure of a true gneiss. It is, then. true incipient banding, and suggests that the gneissic structure in the south of the main granite area has been induced on the rock when it was in a fluid or semi-fluid condition, rather than when it was solid, in contrast to what we have supposed to have been the case in the fine banded gneiss.

The imposition of a gneissic structure on the granite in the south suggests the operation of dynamic forces in that quarter, and it follows that the crystalline rocks of the Khasi Hills may have been disturbed by impulses originating in a directly opposite direction to the later Himalayan movements.

The banded granite-gneiss is seen in the valley of the Umngi below Mawsynram. Higher up the valley three or four miles to the north the granite shows no gneissic structure, and elsewhere, apart from the orientation of the felspars, suggests in the field no reaction to dynamic forces, but under the microscope strain shadows are frequently seen, and the orthoclase usually shows the microcline type of twinning, which may or may not have been induced by pressure.

To the south-west the granite mass is faulted against the gneiss along the line of the upper waters of the Um Shyrhap. I have not seen a section of the fault in question, but the straightness of the

junction running from the north-west to the south-east is very striking. There are few good rock exposures, but enough to determine the boundary, and the striking difference in topography between the two sides of the valley is itself decisive. Elsewhere the granite lies irregularly intruded in the gneiss, and large and small dykes of it radiate through the metamorphic rock in all directions.

From the scanty evidence available it is not possible to form an accurate conception of the true form of this granite mass, but that it does not occupy a simple shaft in the gneiss is indicated by two exposures of the latter rock south of Mar Shillong. Here the country seems built entirely of granite, but the head-waters of the Um Sala, which flows westward from Rangmaw repeatedly expose fine gneiss in the stream bed. This gneiss is intruded by many granite veins, and the granite overlies it and forms the valley sides. Here, then, the granite has filled a horizontal cavity in the gneiss, and has not merely welled up vertical fissures and pipes.

The veins of granite which traverse the small exposures of gneiss in this stream bed are of interest. One of them, only about 18 inches wide, has the pink phenocrysts of felspar fully developed, and ranging in size up to more than an inch in length. The vein itself runs with, and not across, the banding of the gneiss, while the felspars are arranged with their long axes parallel to its walls.

Apart from this main north-eastern granite mass, intrusions of granite occur very frequently in the west. Their presence is usually indicated by groups of boulders in the long grass of a hill top or by fragments in the scree of a jungle-covered slope, and I gave up my attempts to map their boundaries. Two, however, are worthy of mention. The first of these, which is probably about a square mile in extent, underlies Lum Nyangram, a sandstone hill which forms a conspicuous feature of the landscape midway between the Nongstoin villages of Nongsynriang and Nongtyniaw. The second forms a firm foundation for a similar hill known as Lum Nongsynrih in the Siemship of Nobosophoh.

Intrusives in the Granite.

To the west of Jadoh in Nongstoin an intrusion of peridotite pierces the granite. In the field the rock is conspicuous owing to its intense blackness and to its peculiar honeycombed weathering. The hand specimen shows a marked "lustre-mottling" which gives the rock an appearance of being composed almost entirely of a dark

mica. Under the microscope it is seen to be much altered. Olivine, mostly converted into serpentine, is set ophitically in an altered bronze-coloured mica only slightly pleochroic. Amongst the products of alteration there is a mineral suggesting the original presence of amphibole. The low ground from which the intrusion crops out is too covered by long grass to permit of the accurate determination of its boundaries, but the rock is an isolated type and occurs nowhere else in the area.

In the bed of the Phud Stew, where it is crossed by the track running south from Rangmaw, a dolerite dyke traverses the granite. It is a fine-grained intergrown mass of pyroxene and laths of plagioclase.

The Sylhet Trap.

The gneiss and granite above described form, in the north, the foundations of the plateau, but south of latitude 25° 15′ this floor is formed of bedded lavas, the Sylhet traps.

Underlying the Cretaceous and confined, as they are, to the area affected by the monocline at the southern edge of the plateau, their distribution at the surface is dependent almost entirely on topography, and they appear only in the valleys and low-lying areas. Their boundaries, in consequence, lie on the valley slopes and seldom permit of accurate mapping. This is especially the case with the northern junction, where the Traps appose the gneiss. The almost straight line shown on the map has been drawn from a set of isolated observations, and therefore only approximately represents the true run of the boundary. It is remarkably straight and in itself suggests a faulted junction.

Medlicott regarded the Trap in Cherrapunji as lying on and against the southern flanks of an ancient mountain mass. Some evidence in support of this contention can be drawn from the gorge of the Kynshiang, for, as high up the river as the K in "Kynshiang R.," in square C·3 of map $78\frac{0}{3}$, there appears to be a pocket of trap lying irregularly in a hollow in the gneiss on the south side of the river. The Trap itself was inaccessible either on foot or by boat, and I was only able to examine it from the northern bank, but that it really was an outlier of the Sylhet Trap was assumed from the unusual occurrence below it of boulders and pebbles of that series in the river-bed. On the whole, the distribution of the series suggests faulting and, of course, the fault, if it exists, is pre-Cretaceous in age.

The Traps consist for the most part of dark blue, bedded, spheroidal andesites. Hornblende and augite both occur in them, and the former mineral often shows "resorption borders." In parts the beds are more glassy and amygdaloidal. The steam cavities are usually filled with calcite. Beds of ash are not rare amongst the lavas, and occasionally large lapilli are seen. Above Malai and in the neighbourhood of Raibah a soft purple friable ash occurs. This seems almost 200 feet thick, and corresponds apparently to the soft ashy beds reported by Medlicott in 1869 south of Mamluh. This friable ash does not seemingly occur everywhere at the same horizon.

The Traps appear to dip south to south-west and at angles varying from 19° to 25°, but this dip does not agree with Medlicott's observations in the Cherrapunji area, where he found northerly dips ranging from 10° to 15°. A journey by boat up the Umngi shows the confusion that may arise by mistaking jointing for bedding. The dip at times agrees roughly with that of the overlying Cretaceous sandstone, but there can be no doubt there is a break between the two series, and the sandstones rest on a denuded surface of the lava.

Cretaceous.

The Cretaceous rocks developed in the district consist of a sandy series of beds laid down on an irregular surface of gneiss, granite and lava flows. They range from about 500 feet thick in the north to about 1,000 feet in the south. In the north they dip two or three degrees to the south and south-west, but as the dip is followed southward, it becomes greater till the rocks plunge in the south-east down to the plains at an angle of about 60°. In the south-west, however, the monocline is less strongly developed, and at Nalikata the dip is about 25° to the S. S. W. From Nalikata north-eastwards this dip is only gradually reduced, so that the monocline in the west is a gentle regular fold striking N. N. W.—E. S. E. while in the east it is a sharp and more sudden bend to the south. Apart from the contour of the gorges, this change in dip and direction of the monocline is exactly expressed by the topography of the country, for in the Cretaceous area the land surface is almost invariably a dip slope.

For a correct understanding of the Cretaceous rocks it is necessary to relate the essentially different nature of their exposures in different parts of the area. There is a marked break in them roughly along the parallel 25° 22′ N. To the north of this latitude the sedimentary beds occur exclusively on hill tops. They were laid down on the

gently undulating plain of gneiss and granite, and have been almost entirely removed by denuding agencies, leaving records of their former extent only in scattered outliers which have been fortunate enough to escape destruction and which form very characteristic flat-topped hills.

In the south, too, the Cretaceous rocks rest on a comparatively flat sea-bed, but along the parallel referred to above the sedimentary series rests on a much more irregular bed. They are to be sought for as often in the valleys as on the hill tops, and there is a marked and sudden increase in their thickness. They lie here, in fact, on an old shore-line against which they are banked. They fill the old valleys which cut through the hills, and undisturbed and practically horizontal though they are, have boundaries which often strikingly traverse the contours.

Valley deposits of Cretaceous rocks, flanked and overlooked by granite hills, occur 1 mile W. S. W. of Rangmaw, and just east of Mawlangwir and with gneiss 1 mile north-west of Phudja-ud. These are associated with junctions between Cretaceous and crystalline rocks, crossing the country without any relation to the contours and therefore marking a change in level of the underlying rocks. A clear section showing the exact relation of the two series can be seen in the valley 1 mile north-west of Phudja-ud in the valley of the Phud Nopgrew. At first this valley runs entirely in crystallines, then, as it deepens, horizontal Cretaceous rocks are developed on the top of its banks. Lower down the Cretaceous rocks traverse it from the south and rise up its northern side against a steep hill of gneiss. The junction with the gneiss is exposed and the sedimentary rock is apposed to an old valley slope. Just north of this place two small streams, which rise very close to one another and flow in opposite directions, have steep and narrow valleys cut in undisturbed Cretaceous rocks enclosed by high-lying crystallines. These two streams are eroding the Cretaceous rocks which were laid down in an old crystalline valley. At Nongmawmairang there is a Cretaceous outlier which forms one side of a deep valley, while the other side is built of gneiss. The horizontal Cretaceous rocks clearly filled in an old gneissic valley.

South of these old valley deposits the Cretaceous rocks are strongly developed. They appear suddenly and thickly developed along an old shore line, and this can be traced running east and west south of Rangthong and north of Phlangmawphra, while there is

little doubt it continues to the west through the obscure country of Langrin. The relations which I have endeavoured to describe are illustrated in the section already given (Plate 27).

From these observations, then, it is clear that the bottom beds of the Cretaceous are not continuous throughout. The northern Cretaceous is younger than its apparent equivalent in the south. Within the Cretaceous period there was a pause in the submergence of the Crystalline land, a steep shore line was cut, and later the incursion of the sea continued and the old line of cliffs was buried. There is no unconformity between the upper and lower sedimentaries, but there was a pause in the transgression of the sea within the Cretaceous period. With this pause in sedimentation in mind, the subdivision of the Cretaceous rocks may be discussed.

Medlicott in the Cherrapunji area divided the Cretaceous into the following series :—

4. Cherra sandstone.
3. Langpar Band—pale sandstone with plants vagariously developed.
2. Mahadeo Beds—glauconitic.
1. Bottom conglomerate. 20 to 100 feet.

These divisions he detected in the plateau area, but to the south found a different facies. There the base of the Cretaceous is a massive sandstone about 40 feet thick, and this he supposes to represent the bottom conglomerate. Above this the Cretaceous series consists of a mass of shales with a few subordinate bands of limestone.

Medlicott did not believe that his bottom conglomerate represented one horizon, but suggested it traversed and coalesced with the upper beds in the north. Though he detected no inter-Cretaceous shore line in the east, he realised that the bottom Cretaceous bed is not a geological horizon throughout the district. This bottom bed in the area with which I dealt is a felspathic sandstone in the non-plateau area. Elsewhere it is either a conglomerate, a coarse grit or a peculiar detrital rock formed from the rotted underlying crystallines.

In the northern Cretaceous hills or "lums," the bottom bed is a coarse, soft felspathic grit with a tendency to develop small pebble beds. This passes upwards into a finer, white, crumbling sandstone and three hundred feet from the base is overlain by a white clay band only two or three feet thick. Such a section is seen on Lum

Nyangram and the hills just south of it. Still further north, near Laitkseh in Nobosophoh this clay band alone is seen and it directly overlies the granite and bears a considerable number of plant stems. Since it is the topmost bed exposed it appears that it more probably represents an argillaceous phase of the Cherra sandstone than any other band. If this be so the northern Cretaceous rocks exposed represent the Langpar band, and this is overlapped by the horizon of the Cherra sandstone.

In the large Cretaceous area south and south-west of Mawlangwir the old valley deposits consist of rotted granite. This is very little sorted by water and passes downward into rotted granite in which the action of running water cannot be detected. It is overlain by a uniform deposit of felspathic grit. The granite was rotted in pre-Cretaceous times and the old land surface was lowered beneath a sea so calm that the rotted rock was barely disturbed.

Just north of Tyrnai the large basal conglomerate is seen. It is about 30 feet thick but its development is local, for it is not seen in the cliffs south of Tyrnai where the felspathic grit extends to the base. In the same latitude, between Mawsynram and Jimpiat the basal conglomerate is seen again but is much thicker here; probably 100 feet of it are exposed. Being south of the old shore line these basal beds are older than those of Lum Nyangram, but I believe they still form part of the Langpar horizon.

On the high platform above Nongkdait there are about 1,000 feet of Cretaceous sandstones. At the base there are about 300 feet of coarse felspathic sandstone, and above this about the same thickness of glauconitic beds, which are in turn succeeded by fine, white, massive sandstones. The same glauconitic band is seen near Laitsohum, south of Mawsynram, and probably represents the Mahadeo beds, while the succeeding series may be correlated with the Langpar band and Cherra sandstones.

It is on the recognition of these glauconitic sandstones as the Mahadeo beds that the identification of the northern sandstone as Cherra and Langpar beds is based. In the extreme south the Cretaceous is more shaly. South of Nongkla and Nangkuba the topmost beds are of a light blue clay which is at least a hundred feet thick. Below this is sandstone which at times tends to a shaly facies and is occasionally limy. In the stream-bed ¼ mile south-west of Nongkla the bottommost bed of the Cretaceous, laid down on the Sylhet trap, is an irregular limestone two to three inches thick. This shaly and

limy phase of the Cretaceous is not developed in the west. The sections in the Jadukata River show a sandy phase from top to bottom.

The Cretaceous rocks in the coal area surveyed are very barren of fossils. My search for them was unrewarded except for indeterminate plant fragments in the north, but Medlicott has correlated them, on fossil evidence obtained in the eastern area, with the Utatur and Ariyalur beds. Dr. Wright of the Whitehall Petroleum Corporation has sent me some fossils he collected in the Cretaceous sandstones ½ mile north-east of Tyrna, east of Cherrapunji. These are referable to *Stigmatopygus elatus* Forbes, a spatangoid which occurs in the Ariyalur beds of Southern India; this tends to confirm Stoliczka's conclusions.[1]

The Nummulitic Limestone.

The Nummulitic Limestone lies conformably on the Cretaceous sandstones and conforms structurally to them: it covers however a much smaller area. Occupying a narrow band of territory bordering the plains it has been entirely removed from the plateau region in all but two small areas, *viz.*, near Mawsynram and south of Nongkdait. From 500 to 1,000 feet thick in the south it thins out very rapidly to the north. This thinning is real and not merely an effect due to denudation in the plateau, for in Mawsynram the summit as well as the base of the limestone is seen. It is, in fact, in this district only sporadically developed in a series of sandstones and coal-bearing shales. It occurs in lenticular masses and but for its occurrence the rocks in which it lies would appear to be Cretaceous.

At Mawsynram coal is developed where the Nummulitic Limestone is thin. This is the condition of affairs at Cherrapunji and records a change from marine to estuarine conditions. In the south where the limestone is thick, coal is never found but oil frequently. This last observation agrees with Dr. Pascoe's records of oil in other parts of Assam and his suggestion of the salt-water origin of petroleum.[2]

In the other outlier of limestone, near Nongkdait, the bed is about 50 feet thick and again its occurrence seems sporadic. In both cases the associated sands and clays are coloured as Nummulitic

[1] *Mem. Geol. Sur. Ind.*, Vol. VII, pp. 181-183.
[2] *Mem. Geol. Sur. Ind.*, Vol. XL, p. 253.

on the map. There is no doubt this is correct for the greater part of the series, though the topmost beds at Nongkdait may be post-Nummulitic, but in the absence of any defined line it is impossible so to separate them.

The situation of the limestone is most unfortunate; apart from the two poor outliers mentioned it is confined to a belt of dense jungle growing on an irregular and steep slope. Exposures are very difficult to find and when detected are usually much obscured by calcareous tufa and vegetation. The straightness of the boundary lines drawn on the map is sufficient evidence itself that I was unable to trace the limestone across country and the boundaries given must be regarded as only very approximate.

The Nummulitic limestone is a pure white rock, very valuable as a source of lime, for which it is extensively quarried south of Cherrapunji. It is massive in structure and shows a succession of fossiliferous bands alternating with beds containing nummulites, with others composed entirely of small foraminifera, and more rarely with bands containing gastropods and corals.

The following is a list of fossils collected and provisionally identified :-

FORAMINIFERA	*Nummulites* sp.
	Many undetermined.
CORALS	*Thamnastræa* sp.
	Litharæa sp.
	Isastræa (*Prionastræa*?).
GASTROPODS	*Phasianella* sp.
	Turritella sp.

Post-Nummulitic Tertiary Rocks.

Above the Nummulitic Limestone and conformably overlying it is a great series of clays and sands of a total thickness of not less than 15,000 feet. These beds form the foothills of the plateau and break down readily on exposure into a fertile soil, which encourages the growth of dense obscuring jungles. It is very difficult to make out a succession in them, for clays and sands succeed one another everywhere, and at present it is only possible roughly to divide a lower series some 5,000 feet thick and in which clays are abundant, from an upper and more sandy series probably 10,000 feet thick.

In the neighbourhood of Hat Mawdon, in the east, they dip typically at about 80° to the south. Five miles to the west, 45° to the south is a usual dip, but in the neighbourhood of the Mukai River a remarkable change comes in, for the dip is reversed and the dip readings range from 54° N. N. E. to 85° N. The reason of this change is not obvious. It may be due to local overfolding or to faulting. That it is due to the former is unlikely for the monocline on the plateau edge, as has been shown, steadily flattens out from east to west. Good exposures of the Cretaceous and Nummulitic rocks on the flanks of the Mukai River and the Bhawal Chara would probably provide the key to the problem, but I was unable to find such. Unaided one can traverse the country only along tracks and in a few of the river-beds. Slow progress, with coolies cutting the jungle, yields poor results and I was compelled to leave the problem unsolved.

Not the least unsatisfactory feature of these Tertiary rocks is the extraordinary absence of fossils. In this area they are apparently devoid of organic remains. It is remarkable that such should be the case, since they appear well capable of the preservation of the hard parts of animals but I am convinced, that though exposures are few, fossils, if they occur at all, are exceedingly rare, since, in the whole area examined, only a few rotted plant stems in clays on the banks of the Khasimara River were found.

Alluvium.

The alluvium was not examined but is coloured a pale umber on the map.

ECONOMIC GEOLOGY.

Coal occurs above the thin Nummulitic limestone at Mawsynram.

Coal.

A seam of good coal 3 feet thick is exposed on the hill a mile south of Rangsokham, but a hundred yards away it is only 6 feet thick and tails out into shale. It is not a bed worth working, for its maximum extent can hardly be more than an acre or two and its thickness is so variable. Quite near to it are two lime kilns in which wood fuel is used. In answer to my enquiries why the local coal was not used in the kilns, the owner told me he had found that the coal did not go far, or, in other words, the occurrence of coal in pockets prevented its economic use.

In the north bank of the Kynshiang, at about "*g*" in the name of the river on the map, a thin bed of coal is seen in the Cretaceous sandstone; it is only 6 inches thick at the most and is therefore only of scientific interest.

Oil.

In the older Tertiaries at the base of the plateau oil seeps to the surface in three localities, which all lie on one line of strike. The three seepages occur, one at Telcherra, a second one a mile to the N. W. of this place within the bend of the Khasimara River, and a third 4½ miles due west of the second locality.

At Telcherra a line of springs issues from the alternating sandy and clayey strata which here dip 50° towards the south. Gas and oil issue with the water. The gas is inflammable and the oil heavy. A boring was put down here probably twenty years ago, the lining of which is still in place; water, gas and oil permanently issue from it. A certain amount of old machinery lies rusting in the jungle. The local people, who were very averse to any new workings being opened, claimed that the company who put down the bore found oil and sent a few small consignments to Calcutta, but that the work was suspended owing to the unhealthiness of the district.

The most westerly seepage is only accessible by cutting a way through dense jungle. The oil reaches the surface on the edge of a small stream and forms a skin on wet recent alluvium. Unfortunately there had been a few hours heavy rain before my visit which had removed most of the surface oil, but by digging down 18 inches a sample of the oil was obtained. It collected in the hole made in about five minutes, and was thick and closely similar to the Telcherra oil. This seepage has never been bored but has according to the guides who took me there, been visited by a European before. The dip of the Tertiary sands in the neighbourhood is about 43°, direction S. S. W.

The third oil seepage, lying between the other two, has not so far as I am aware been visited by a European. Like the second seepage the oil here actually occurs in a patch of local alluvium, but no doubt it originates in the underlying Tertiary strata. The spot lies in an orange grove and the orange pickers have dug a hole about two feet deep in the ground, in the bottom of which the oil collects and from which they take it and use it directly in their lamps. It is light and burns freely with a bright flame. As in the case of

the other two seepages gas bubbles out with the oil but here there is little water.

These three occurrences of oil, approximately along one line of strike, indicate the existence of an extensive and possibly remunerative oil horizon in the Tertiary strata. The oil is seeping out, however, along the broken end of a monocline. The emission of gas suggests that the oil is under pressure. There are unquestionably minor folds in the Tertiary rocks but there is no suggestion of good "oil structure" in the neighbourhood.

The Tertiary strata stand here at a steep angle dipping to the south. Probably they flatten out under the alluvium of the plains where, should they be folded into impervious domes, may lie oil-fields awaiting discovery; the only method of proving their existence is by blind boring, and that is obviously an extremely speculative proposition.

Copper.

While working in the southern part of the district I met a party prospecting for copper in the Sylhet Trap. Native copper has recently been discovered in this formation in the bed of the Um Sohryngkew below Mawsmai, south of Cherrapunji. The metal occurs in leaves developed on a fault face and its discovery naturally led to prospecting in other areas where the Sylhet trap is exposed. I am not aware that the prospectors located any copper in the area surveyed by me, but I found indications of its presence in the bed of the Rilang River, ½ mile west of point "187", below Langpa in Langrin.

Here the gorge is built of light granulitic gneiss and a stream, emerging from a fault-plane has deposited a thin, blue-green film of a copper salt on the rock face. Owing to the absence of crystal forms and to the extreme thinness of the film, it is impossible definitely to determine this salt; Dr. Christie has kindly examined it for me by microchemical methods and asserts that it is a basic sulphate of copper, probably of the nature of brochantite.

This copper deposit is found about a mile away from the Sylhet trap, but it is not impossible that an undetected outlier of these lavas occurs nearer to it, and I cannot doubt that its origin is to be sought in the trap and not in the gneiss. An attempt to explore this deposit would be a very speculative undertaking.

Iron.

The unusual amount of magnetite that occurs in the coarse pink granite of the Nobosophoh area has already been mentioned. I am informed that

in the Nongspung area this magnetite is extracted from the rotten granite by washing and that in former times it was worked in many parts of the Khasi Hills. Iron so obtained cannot seriously compete with the rich iron fields of India and the industry has no prospects.

Building Stone.

The Cretaceous sandstones form in part a good building stone. The whiter varieties, free from iron stains, are valued by the Khasis for building the memorial pillars and resting places they are so fond of erecting.

GEOLOGICAL HISTORY.

In conclusion it may not be out of place briefly to review the history of the area. The Shillong plateau consists of two distinct elements. There is the peninsular element consisting of gneiss and granite (with the Pre-Cambrian Shillong series) overlain by the Cretaceous rocks, which are an extension of the Cretaceous of Southern India. Above these is what we may call the Sub-Himalayan element, comprising the Tertiary deposits.

The great southern ocean of Cretaceous times whose northern shore ran from the Cape of Good Hope north-eastwards to Cape Comorin and the Sylhet district, swelled up over the land in Cenomanian times. It appears probable that the Cretaceous of the Khasi Hills was deposited during this transgression. Were the Indian ocean to rise five to six thousand feet to-day and cover the Shillong plateau with littoral deposits, these sediments would be laid down on the gneiss and granite precisely in the manner that the Cretaceous rocks were formed. The deposits would fill in the valleys and climb up the hills. They would have an original dip to the south owing to the gentle slope of the modern plateau and they would structurally be indistinguishable from the Cretaceous rocks which now exist in the north of the area mapped. These latter are totally undisturbed; they dip south two or three degrees, and it is suggested this dip is not produced by movements of the earth's crust but is a natural dip,—the original slope of beds laid down on a sloping shore. Medlicott was of this opinion and he attributed the southern monocline to subsidence in the south and not to elevation in the north.

It is quite possible that the Cretaceous sandstones which now form the table mountains of the Khasi plateau are exactly in the position in which they were formed, and that they have neither been elevated nor depressed but are literally the tide marks of

the Cretaceous sea. Such an idea is less speculative than at first appears. To suggest, as would no doubt be popular, that the plateau sandstones have been elevated some five thousand feet without disturbance is pure speculation. There is no evidence of elevation and one is not entitled to assume that it has taken place.

While the southern ocean in mid-Cretaceous times was rising up the east coast of India and submerging the gneiss hills of Assam, the ancient Tethys, with a distinct Cretaceous fauna, was flooding India in the district of the Gulf of Cambay and, with the coming of the Eocene, gave birth to the Nummulitic fauna. With this fauna well established in its waters, changes in level, according to my interpretation of the facts, brought the Tethys into connection with the Assam branch of the southern ocean. The geographical change that mingled the two waters brought about a change in conditions. The sea-bed was undisturbed but limestones were formed on it in place of sandstones. The Nummulitic fauna replaced the Cretaceous by invasion and the invaders easily replaced the older fauna in the south, for the new conditions of deposition were suitable to them and unfavourable to the aboriginal types.

In the Mawsynram region and north of Cherrapunji however the Eocene limestone is only poorly developed, and sandstones of that age very similar to the Cretaceous sandstones were formed. Conditions there would be more favourable to the southern ocean types than to the fauna of the Tethys, and in the deposits of that area a great battle must have been fought. Remains of friend and foe might be expected to occur; both Cretaceous and Eocene forms should be found side by side. Unfortunately in my survey the small Mawsynram Eocene outlier yielded fossils only in the limestone, and these were all of Eocene types. The absence of fossils in the topmost Cretaceous beds has been one of the chief disappointments in the work.

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RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1922 [September.

THE MINERAL PRODUCTION OF INDIA DURING 1922. BY E. H. PASCOE, M.A., SC.D. (CANTAB.), D.SC. (LOND.), F.G.S., F.A.S.B., *Director, Geological Survey of India.*

CONTENTS.

INTRODUCTION.

THE method of classification adopted in the first Review of Mineral Production published in these Records (Vol. XXXII), although admittedly not entirely satisfactory, is still the best that can be devised under present conditions. As the methods of collecting the returns become more precise and the machinery employed for the purpose more efficient, the number of minerals included in Class I—for which approximately trustworthy annual returns are available—increases, and it is hoped that before long the minerals of Class II—for which regularly recurring and full particulars cannot be procured—will be reduced to a very small number. In the case

of minerals still exploited chiefly by primitive native methods, and thus forming the basis of an industry carried on by a large number of persons each working independently and on a very small scale, the collection of reliable statistics is impossible, but the total error from year to year is not improbably approximately constant and the figures obtained may be accepted as a fairly reliable index to the general trend of the industry. In the case of gold, the small indigenous alluvial industry contributes such an insignificant portion to the total outturn that any error from this source may be regarded as negligible.

In the previous Review the statement of values of the Indian Mineral Production for the year under review and for the preceding year was drawn up for purposes of comparison on the basis of an exchange value of the rupee at 2*s.* for 1920, and 1*s.* 4*d.* for 1921. The average value of the Indian rupee during the year 1922 was 1*s.* $3\frac{1}{3}\frac{9}{2}d.$: the highest value reached was 1*s.* $4\frac{1}{8}d.$ and the lowest 1*s.* $2\frac{1}{1}\frac{5}{6}d.$ The values shewn in table 1 and all following tables of the present Review are given on the basis of 1*s.* 4*d.* to the rupee.

From table 1 it will be seen that there has been an apparent increase of £2,00,000 or over 9 per cent. in the value of the total production over that of 1921. The value figures, however, are largely artificial. In some instances, although the output has fallen in quantity, it has increased in value; such increase does not necessarily give a true indication of the state of an industry.

The number of mineral concessions granted during the year amounted to 672 as against 651 in the preceding year; of these 562 were prospecting licenses, and 110 were mining leases.

TABLE 1.—*Total value of Minerals for which returns of Production are available for the years 1921 and 1922.*

——	1921. (Rupee=1*s.* 4*d.*)	1922. (Rupee—1*s.* 4*d.*)	Increase.	Decrease.	Variation per cent.
	£	£	£	£	
Coal	8,673,377	9,755,343	1,081,966	..	+12·5
Petroleum	5,603,975	7,185,043	1,581,068	..	+28·2
Gold	2,050,576	1,857,565	..	193,011	—9·4
Lead and lead-ore .	784,586	945,137	160,551	..	+20·5
Carried over .	17,112,514	19,743,088	2,823,585	193,011	

TABLE 1.—*Total value of Minerals for which returns of Production are available for the years 1921 and 1922*—contd.

——	1921. (Rupee 1s. 4d.)	1922. (Rupee 1s. 4d.)	Increase.	Decrease.	Variation per cent.
	£	£	£	£	
Brought forward .	17,112,514	19,743,088	2,823,585	193,011	
Manganese-ore (a) .	1,537,068	915,093	..	621,975	—40·5
Salt	712,147	819,218	77,071	..	+10·4
Silver . . .	593,008	675,234	82,226	..	+13·8
Building materials .	422,219	394,833	..	27,386	—6·5
Mica (b) . . .	426,274	385,683	..	40,591	—9·5
Saltpetre . . .	357,032	234,866	..	122,166	—34·2
Tin and tin-ore . .	162,770	188,963	26,193	..	+16·1
Jadeite (b) . . .	126,535	165,798	39,263	..	+31·03
Iron-ore . . .	140,555	104,428	..	36,127	—25·7
Zinc-ore (b) . . .	20,009	90,505	70,496	...	352·3
Ruby, Sapphire and Spinel.	50,164	48,487	..	1,677	— 3·3
Tungsten-ore . .	29,292	25,035	..	4,257	—14·5
Chromite . . .	36,492	24,086	..	12,406	—33·9
Copper-ore . . .	32,560	20,509	..	12,051	—37·01
Clays	37,378	18,218	..	19,160	—51·3
Magnesite . . .	15,632	16,046	414	..	+ 0·3
Alum	4,293	6,651	2,358	..	+ 54·9
Diamonds . . .	4,865	6,110	1,245	..	+ 25·6
Gypsum . . .	2,267	4,298	2,031	..	+89·6
Ochre	2,174	3,812	1,638	..	+75·1
Barytes . . .	3,486	3,200	..	286	—20·6
Fuller's earth . .	966	2,444	1,478	..	+153·0
Steatite . . .	4,119	2,426	..	1,693	—41·1
Monazite . . .	30,959	1,871	..	29,088	—93·9
Zircon	..	1,280	1,280	..	..
Ilmenite . . .	..	1,200	1,200	..	..
Bauxite . . .	3,280	(c)1,063	..	2,217	—67·6
Asbestos . . .	884	701	..	183	—20·7
Amber	1,123	131	..	992	—88·3
Soda	24	68	44	..	+183·3
Aquamarine and beryl .	1,274	..	..	1,274	..
Apatite . . .	231	..	..	231	..
Antimony-ore . .	70	..	..	70	..
Corundum . . .	55	..	..	55	..
Graphite . . .	52	..	..	52	..
Molybdenite . .	13	..	..	13	..
Total .	**21,901,784**	**23,905,345**	**3,130,522**	**1,126,961**	**+9·15**
			+2,003,561		

(a) Value f. o. b.
(b) Export values.
(c) Excludes the value of 932 tons.

II.—MINERALS OF GROUP I.

Chromite.	Graphite.	Manganese.	Ruby, Sapphire and Spinel.	Silver.
Coal.	Iron.	Mica.	Salt.	Tin.
Copper.	Jadeite.	Monazite.	Saltpetre.	Tungsten.
Diamonds.	Lead.	Petroleum.		Zinc.
Gold.	Magnesite.			

Chromite.

There was a decrease in the production of chromite from 34,762 tons in 1921 to 22,777 tons in the year under review. Baluchistan is mainly responsible for this decrease.

TABLE 2.—*Quantity and value of Chromite produced in India during 1921 and 1922.*

—	1921.			1922.		
	Quantity.	Value. (Rupee =1*s.* 4*d.*)		Quantity.	Value. (Rupee =1*s.* 4*d.*)	
	Tons.	Rs	£	Tons.	Rs.	£
Baluchistan—						
Zhob . .	25,122	3,76,826	25,122	18,548	2,88,227	19,215
Bihar and Orissa—						
Singhbhum .	2,605	52,610	3,507	1,147	15,660	1,044
Mysore—						
Hassan . .	6,486	1,16,748	7,783	2,120	38,160	2,544
Mysore . .	549	1,198	80	962	19,240	1,283
Total .	**34,762**	*5,47,382*	*36,492*	**22,777**	*3,61,287*	*24,086*

Coal.

There was a decrease during the year of nearly 292,000 tons, or somewhat over 1·5 per cent., in the output of coal. This decrease was due largely to Bihar and Orissa. Central India and the Central Provinces also shewed substantial reductions, and Rajputana a drop of over 60 per cent. Bengal and Assam both shew considerable increases. The decrease shewn by Bihar and Orissa was due chiefly to the Giridih field, that in Central India to Umaria and

that in the Central Provinces mainly to the Ballarpur field. In Hyderabad State the Singareni field again shewed a decrease amounting to nearly 42,000 tons, while the Sasti coalfield opposite to Ballarpur in British territory yielded a little over 4,000 tons short of its maiden effort in 1921 of some 42,600 tons. There was a general increase in the pit's mouth value of coal, except in Baluchistan and Rajputana, the rate of increase varying from as little as Re. 0-0-2 in the Punjab to Rs. 4-8-6 in Burma ; the increase in the fields of Bihar and Orissa averaged Re. 0-8-7 and in Bengal Re. 1-14-5. During the previous year, the existence was proved in the Talcher coalfield of considerable quantities of good steam coal, and this field is now in course of commercial development.

TABLE 3.—*Average Price (per ton) of Coal extracted from the Mines in each province during the years 1921 and 1922.*

—	1921.			1922.		
	Rs.	A.	P.	Rs.	A.	P.
Assam	7	13	4	8	5	4
Baluchistan	14	1	8	13	7	5
Bengal	7	11	8	9	10	1
Bihar and Orissa	6	6	10	6	15	5
Burma	11	7	6	16	0	0
Central India	5	11	6	5	13	6
Central Provinces	7	0	0	7	10	7
Punjab	14	13	8	14	13	10
Rajputana	8	13	4	7	2	2

TABLE 4.—*Origin of Indian Coal raised during 1921 and 1922.*

—	Average of last five years.	1921.	1922.
	Tons.	Tons.	Tons.
Gondwana coalfields	19,349,101	18,843,792	18,520,341
Tertiary coalfields	416,431	459,155	490,645
Total	19,765,532	19,302,947	19,010,986

TABLE 5.—*Provincial Production of Coal during the years 1921 and 1922.*

Province.	1921.	1922.	Increase.	Decrease.
	Tons.	Tons.	Tons.	Tons.
Assam	312,465	348,103	35,638	..
Baluchistan	54,627	60,135	5,508	..
Bengal	4,259,642	4,328,986	69,344	..
Bihar and Orissa	12,990,481	12,711,328	..	279,153
Burma	300	172	..	128
Central India	192,034	161,231	..	30,803
Central Provinces	712,914	675,916	..	36,998
Hyderabad	688,721	642,880	..	45,841
Punjab	67,242	67,180	..	62
Rajputana	24,521	15,055	..	9,466
Total	**19,302,947**	**19,010,986**	**110,490**	**402,451**

TABLE 6.—*Output of the Gondwana Coalfields for the years 1921 and 1922.*

	1921.		1922.	
	Tons.	Per cent. of Indian total.	Tons.	Per cent. of Indian total.
Bengal, Bihar and Orissa—				
Bokaro	929,143	4·81	1,037,171	5·46
Daltonganj	36,590	0·19	31,933	0·17
Giridih	818,580	4·24	659,101	3·47
Jainti	105,652	0·55	96,612	0·51
Jharia	10,068,856	52·16	9,936,299	52·27
Rajmahal Hills	2,170	0·01	2,801	0·01
Ramgarh	..	..	4,565	0·02
Rampur (Raigarh-Hingir)	77,277	0·40	68,618	0·36
Raniganj	5,211,855	27·00	5,203,214	27·37
Central India—				
Sohagpur	37,060	0·19	42,693	0·22
Umaria	154,974	0·80	118,538	0·62
Central Provinces—				
Ballarpur	171,425	0·89	132,680	0·70
Betul	..	..	1,069	0·01
Mohpani	89,623	0·47	84,996	0·45
Pench Valley	449,311	2·33	453,484	2·39
Shahpur	210	..	..	.
Yeotmal	2,345	0·01	3,687	0 02
Hyderabad—				
Sasti	42,674	0·22	38,522	0·20
Singareni	646,047	3·35	604,358	3·18
Total	**18,843,792**	**97·62**	**18,520,341**	**97·43**

TABLE 7.—*Output of the Tertiary Coalfields for the years 1921 and 1922.*

—	1921. Tons.	1921. Per cent. of Indian total.	1922. Tons.	1922. Per cent. of Indian total.
Assam—				
Khasi and Jaintia Hills .	443	1·62	453	1·83
Makum	269,198		291,747	
Naga Hills . . .	42,824		55,903	
Baluchistan—				
Kalat, Mach, Sor Range .	23,374	0·28	26,269	0·31
Khost	31,253		33,866	
Burma				
Loi-an (Kalaw) . . .	300	..	172	..
Punjab—				
Jhelum	50,639	0·35	47,832	0·35
Mianwali	11,852		14,301	
Shahpur	4,751		5,047	
Rajputana—				
Bikaner	24,521	0·13	15,055	0·08
Total .	**459,155**	2·38	**490,645**	2·57

The total production in 1921, although an improvement on that of 1920, was nevertheless nearly 3 million tons below the output of 1919, and the coal situation became so acute that it was found necessary early in 1921 to prohibit the export of Indian coal to foreign ports. The effects of this step are seen in the export statistics, which shew a fall from a total of nearly 1¼ million tons in 1920 to 275,000 tons in 1921, and to a mere 77,000 tons in the year under review. On the other hand, the imports rose from the insignificant figure of under 40,000 tons in 1920 to over 1 million tons in 1921, and to nearly 1½ million tons in 1922, 718,000 tons coming from the United Kingdom, 389,000 from South Africa, 56,000 from Japan, and the balance from Australia, New Zealand and other countries.

TABLE 8.—*Exports of Indian Coal and Coke during 1921 and 1922.*

—	1921.			1922.		
	Quantity.	Value. (Rupee = 1*s.* 4*d.*)		Quantity.	Value. (Rupee = 1*s.* 4*d.*)	
	Tons.	Rs.	£	Tons.	Rs.	£
To—						
Aden and Dependencies	17,575	2,01,166	13,411	..	..	..
Ceylon	236,179	32,01,578	213,439	76,466	10,03,824	66,922
Straits Settlements (including Labuan).	10,682	1,52,100	10,140	..	..	..
Sumatra	6,251	87,514	5,834	..	..	..
Egypt	200	400	27	..	..	..
Other Countries	2,761	1,11,119	7,408	13	543	36
TOTAL	273,648	37,53,877	250,259	76,479	10,04,367	66,958
Coke	1,923	93,518	6,234	632	36,997	2,466
Total of Coal, Coke	**275,571**	*38,47,395*	*256,493*	**77,111**	*10,41,364*	*69,424*

TABLE 9.—*Imports of Coal, Coke and Patent Fuel during 1921 and 1922.*

—	1921.			1922.		
	Quantity.	Value. (Rupee = 1*s.* 4*d.*)		Quantity.	Value. (Rupee = 1*s.* 4*d.*)	
	Tons.	Rs.	£	Tons.	Rs.	£
From—						
Australia (including New Zealand).	111,384	37,58,254	250,550	17,849	6,57,330	43,822
Japan	68,071	24,07,987	160,532	55,547	21,21,080	141,405
Natal	306,235	1,13,16,644	754,443	231,548	72,07,760	480,517
Portuguese East Africa	156,555	58,74,560	391,637	157,122	57,74,455	384,964
United Kingdom	436,012	1,86,17,067	1,241,138	718,487	2,78,80,912	1,858,727
Other Countries	6,430	1,49,323	9,955	11,413	2,64,271	17,618
TOTAL	1,084,687	4,21,23,835	2,808,255	1,191,966	4,39,05,808	2,927,053
Coke	6,051	5,01,311	33,421	28,673	14,52,654	96,844
Patent Fuel	11	2,502	167	..	..	..
Total of Coal, Coke, etc.	**1,090,749**	*4,26,27,648*	*2,841,843*	**1,220,639**	*4,53,58,462*	*3,023,897*

The average number of persons employed daily in the coal-fields during the year decreased by 4,966 or 2·4 per cent., and the average output per person employed shewed very little improvement, being 94·6 tons against 93·76 tons in the preceding year; in 1919 this figure was 111·05 tons. The total number of deaths by accident was 243, corresponding to a death-rate of 1·21 per thousand persons employed, which compares favourably with 286 deaths by accident and a death-rate of 1·39 per thousand in 1921.

TABLE 10.—*Average number of persons employed daily in the Indian Coalfields during 1921 and 1922.*

Province.	Number of persons employed daily.		Output per person employed.	Number of deaths by accident.	Death-rate per 1,000 persons employed.
	1921.	1922.			
Assam	3,389	3,636	95·7	8	2·2
Baluchistan	1,330	1,492	40·3	18	12·1
Bengal	45,813	44,893	96·4	58	1·3
Bihar and Orissa . .	126,431	119,790	106·1	112	0·9
Burma	270	65	2·6	1	15·4
Central India	1,967	2,595	62·1	2	0·8
Central Provinces . .	12,152	13,255	51·0	9	0·7
Hyderabad	12,502	13,402	48·0	32	2·4
Punjab	1,898	1,686	39·8	3	1·8
Rajputana	127	99	152·1	..	..
Total .	**205,879**	**200,913**	..	243	..
AVERAGE .	..	..	94·6	..	1·21

Copper.

The output of copper-ore in Singhbhum has been maintained at a fairly steady level since 1919, following the commencement of smelting operations at the Rakha Mines during the year 1918. The output in 1919 was 32,756 tons, which fell in 1920 to 28,167 tons, valued at £42,250, and again in 1921 to 23,089 tons, valued at £32,560. The output during 1922 rose to 30,764 tons, valued at £20,509. The Rakha Mines deposit is a low-grade sulphide ore containing from 2 to 4 per cent. of copper, but a slightly improved grade of ore has recently been struck. Three other companies are prospecting in the Singhbhum belt; and in one place a 10—12 per cent. ore has been obtained. Smelting operations by the Cape Copper Company, commenced during the year 1918, resulted in the production of 980¼ tons of refined copper in the year 1919, 512 tons in 1920, 1,143 tons in 1921 and 1,037 tons in 1922. There was a

small production of 40 tons of copper-ore in Mysore State, as against 30 tons in the preceding year.

Diamonds.

The output of diamonds from Central India amounted to 171·39 carats, valued at Rs. 91,648 (£6,110), as against 126·1 carats, valued at Rs. 72,970 (£4,865), in the preceding year.

Gold.

The continuous decrease in the output of gold in India from the maximum production of 616,728 ozs. reached in 1915, was interrupted during the year 1922, when the total output of gold was 438,015·04 ozs., valued at £1,857,565, as compared with an output of 432,722·59 ozs., valued at £2,050,576, in the previous year. This increase was due almost entirely to yields from cyanide slags in Mysore.

TABLE 11.—*Quantity and value of Gold produced in India during the years 1921 and 1922.*

—	1921.			1922			Labour.
	Quantity	Value (Rupee = 1*s* 4*d*)		Quantity	Value (Rupee = 1*s* 4*d*)		
	Oz	Rs.	£	Oz	Rs.	£	
Burma—							
Katha . .	15·66	927	62	12·01	815	54	36
Upper Chindwin.	26·50	3,115	208	12	1,280	85	74
Madras—							
Anantapur .	10,108(*a*)	7,21,359	48,091	8,388(*a*)	6,08,673	40,578	509
Mysore . .	422,533(*b*)	3,00,30,373	2,002,025	429,559·6(*c*)	2,72,50,073	1,816,672	23,297
Punjab . .	39·43	2,853	190	40·8	2,638	176	79
United Provinces	..	..	..	2·63	(*d*)	..	10
Total .	**432,722·59**	*3,07,58,627*	*2,050,576*	**438,015·04**	*2,78,63,479*	*1,857,565*	**24,007**

(*a*) Fine gold.
(*b*) Contains 380,780·49 ozs. fine gold.
(*c*) Contains 381,955·18 ozs. fine gold.
(*d*) Not available.

Graphite.

No output of graphite was recorded in 1922 from the mines which were in operation in the previous year and which yielded some 25 tons. Mysore only reported a small output of 20 tons.

Iron.

There was a considerable decrease in the output of iron-ore amounting to over $33\frac{1}{3}$ per cent., *viz.*, from 942,084 tons, valued at Rs. 21,08,329 (£140,555), to 625,274 tons, valued at Rs. 15,66,430 (£104,428). This decreased production is more apparent than real and is attributable to the fact that owing to the incompletion of railway sidings in the Mayurbhanj State in 1921, the Tata Iron and Steel Company were unable to despatch more than about $\frac{4}{5}$ths of their raisings, the rest being dumped in the stock pile; although the raisings for 1922 total only 378,134 tons, the total ore despatched from Mayurbhanj was 393,409 tons. The production in Singhbhum is mostly that of the Bengal Iron Company, the Indian Iron and Steel Company being responsible for 22,947 tons from their quarrying at Gua; in 1921 the latter Company's share of the raisings in Singhbhum was as much as 102,723 tons.

The Tata Iron and Steel Company produced 227,683 tons of pig iron, 111,500 tons of steel, including rails, and 1,810 tons of ferro-manganese, showing a decrease in each case over the previous year, while the Bengal Iron Company produced 110,744 tons of pig iron and 28,186 tons of cast iron castings, showing increases in both cases. The Indian Iron and Steel Company commenced turning out pig iron, railway sleepers and railway "chairs" in November 1922. In the Central Provinces the number of indigenous furnaces in operation fell from 155 in 1921 to 148 in 1922, the decrease being mainly in the Drug district and mostly due to the *aghoria lohar* either having left the villages or taken to other occupations.

The output in Burma is by the Burma Corporation, Limited, and is used as a flux in lead-smelting.

TABLE 12.—*Quantity and value of Iron-ore produced in India during 1921 and 1922.*

—	1921.			1922.		
	Quantity.	Value. (Rupee = 1*s.* 4*d.*)		Quantity.	Value. (Rupee = 1*s.* 4*d.*)	
	Tons.	Rs.	£	Tons.	Rs.	£
Bihar and Orissa—						
Mayurbhanj	651,495	13,02,990(*a*)	86,866	378,184	9,45,335	63,022
Sambalpur	797	4,602	307	798	5,495	366
Singhbhum	237,173	5,88,774	39,251	215,746	4,93,316	32,888
Burma—						
Mandalay	11,916	47,664(*a*)	3,178	..	..	..
Northern Shan States	37,915	1,51,660(*a*)	10,110	27,680	1,10,720(*a*)	7,381
Central Provinces	2,433	9,925	662	2,891	11,564	771
Other Provinces and States	355	2,714	181	25	(*b*)	..
Total	**942,084**	*21,08,329*	*140,555*	**625,274**	*15,66,430*	*104,428*

(*a*) Estimated. (*b*) Not available.

Jadeite.

The output of jadeite in Burma was more than doubled in the year under consideration, rising from 3,815 cwts., valued at Rs. 7,01,673 (£46,778), in 1921 to 7,724·7 cwts., valued at Rs. 8,69,340 (£57,956), in 1922. The export figures, from which a better idea of the extent of the jadeite industry is obtainable, for the year 1921-22 were 5,374 cwts., valued at Rs. 18,98,030 (£126,535), rising to 7,805 cwts., valued at Rs. 24,86,969 (£165,798), in 1922-23.

Lead.

The production of lead-ore at the Bawdwin mines shewed a further increase of some 28,000 tons; and the total amount of metal extracted increased from 33,717 tons, valued at Rs. 1,17,46,967 (£783,131), to 39,214 tons, valued at Rs. 1,41,71,392 (£944,759). The quantity of silver extracted rose from 3,555,021 ozs., valued at Rs. 88,20,855 (£588,057), to 4,205,584 ozs., valued at Rs. 1,00,39,362 (£669,291). The value of the lead extracted increased from Rs. 348 (£23·2) per ton in 1921 to Rs. 361 (£24·1) per ton in the year under review, and that of silver decreased from Rs. 2-7-8 (39·7*d.*) to Rs. 2-6-2 (38·2*d.*) per oz.

The increase in production of lead-ore at the Bawdwin mines recorded in 1921 was repeated in 1922 to the extent of some 28,000 tons.

TABLE 13.—*Production of Lead and Silver Ore during 1921 and 1922.*

—	1921.					1922.				
	QUANTITY.	VALUE. (RUPEE = 1*s.* 4*d.*)				QUANTITY.	VALUE. (RUPEE = 1*s.* 4*d.*)			
	Lead-ore.	Lead-ore and lead.		Silver.		Lead-ore.	Lead-ore and lead.		Silver.	
	Tons.	Rs.	£	Rs	£	Tons.	Rs.	£	Rs.	£
Burma—										
Northern Shan States	144,089	1,17,46,967(*a*)	783,131	88,20,855(*b*)	588,057	172,017	1,41,71,392(*c*)	944,759·5	1,00,39,362(*d*)	669,291
Southern Shan States	138·1	21,812	1,454	..	..	48·8	5,625	375	..	..
Central Provinces—										
Drug . . .	0·5	10	1	..	..	1	36	2·4	..	..
Total .	**144,227·6**	*1,17,68,789*	*784,586*	*88,20,855*	*588,057*	**172,066·8**	*1,41,77,053*	*945,136·9*	*1,00,39,362*	*669,291*

(*a*) Value of 33,717 tons of lead extracted.
(*b*) Value of 3,555,021 ozs. of silver extracted.
(*c*) Value of 39,214 tons of lead extracted.
(*d*) Value of 4,205,584 ozs. of silver extracted.

Magnesite.

The check on the revival of the Indian magnesite industry recorded in 1920 disappeared during 1921, when the output increased by nearly 6,000 tons, reaching the highest figure that has yet been recorded, namely 20,000 tons. This record was nearly maintained during 1922, the figure being well over 19,000.

TABLE 14.—*Quantity and value of Magnesite produced in India during 1921 and 1922.*

—	1921.			1922.		
	Quantity.	Value. (Rupee = 1s. 4d.)		Quantity.	Value. (Rupee = 1s. 4d.)	
	Tons.	Rs.	£	Tons.	Rs.	£
Madras—						
Salem	17,152	2,05,824	13,722	18,417	2,21,004	14,734
Mysore—						
Hassan	50	500	33	..	..	..
Mysore	2,815	28,150	1,877	856	19,688	1,312
Total .	**20,017**	*2,34,474*	*15,632*	**19,273**	*2,40,692*	*16,046*

Manganese.*

During 1922 the output of manganese-ore in India fell from 679,286 tons, valued at £1,537,068 f. o. b. at Indian ports, in the previous year to 474,401 tons, valued at £915,093 f. o. b. Indian ports. The Central Provinces was responsible for the greater part of this decrease, which is attributable to the small demand for ore in the early part of the year, and tol a good harvest which absorbed most of the labour. It will be noticed from tables 15 and 16 that the exports during the year were about 400,000 tons more than the production, and evidently included the accumulated stocks of previous years.

The figures of distribution of the exported ore according to destination shew that this increase in exports was due chiefly to the enormous increase of over 150,000 tons in the quantity of ore taken

by the United Kingdom, and denote a recovery from the disastrous reduction in steel-smelting resulting from the coal strike of 1920 and high labour charges. With the exception, however, of the United States. Japan and Germany, all other importers of Indian manganese-ore received substantially larger supplies than during the previous year, France doubling her previous quantity. The United States imports from India dropped over 70 per cent. The large exports to Belgium are in part for transmission to Germany.

TABLE 15.—*Quantity and value of Manganese-ore produced in India during 1921 and 1922.*

—	1921.		1922.	
	Quantity.	Value f. o. b. at Indian ports.	Quantity.	Value f. o. b. at Indian ports.
	Tons.	£	Tons.	£
Bihar and Orissa—				
Gangpur	19,823	45,427	16,372	32,062
Singhbhum . . .	425	974	..	..
Bombay—				
Chota Udaipur . . .	29,467	67,528	17,193	33,670
Panch Mahals . . .	44,276	101,465	39,703	77 752
Central Provinces—				
Balaghat	253,599	581,160	169,182	331,315
Bhandara	69,291	158,790	41,143	80,572
Chhindwara	43,661	100,055	33,473	65,551
Nagpur	186,491	427,372	132,152	258,798
Madras—				
Sandur State . . .	567	921	1,470	1,972
Vizagapatam . . .	16,593	26,964	7,845	10,525
Mysore—				
Chitaldrug	1,000	1,750	1,725	2,487
Shimoga	13,493	23,612	14,018	20,209
Tumkur	600	1,050	125	180
Total .	**679,286**	***1,537,068***	**474,401**	***915,093***

TABLE 16.—*Exports of Manganese-ore during 1921 and 1922 according to Ports of Shipment.*

Port.	1921.	1922.
	Tons.	Tons.
Bombay	271,826	389,442
Calcutta	259,621	371,708
Vizagapatam	8,442	13,710
Mormugao	10,874	87,917
Total	**550,763**	**862,777**

TABLE 17.—*Exports of Manganese-ore during 1921 and 1922.*

—	1921.			1922.		
	Quantity.	Value. (Rupee = 1s. 4d.)		Quantity.	Value. (Rupee = 1s. 4d.)	
	Tons.	Rs.	£	Tons.	Rs.	£
To—						
United Kingdom	96,759	24,05,918	160,395	247,517	50,80,464	338,698
Belgium	228,764	55,71,269	371,418	299,656	70,66,054	471,070
France	79,855	17,95,707	119,714	149,065	33,56,702	223,780
Italy	9,600	3,07,300	20,486·7	11,700	2,95,650	19,710
Germany	9,100	2,12,105	14,140	8,917	1,76,595	11,773
Netherlands	27,200	6,92,000	46,133	30,100	5,60,250	37,350
Japan	2,250	58,225	3,881·7	1,351	36,714	2,448
United States of America	86,360	23,28,025	155,261·6	24,024	6,81,383	45,425
Other Countries	1	555	37	1,000	22,500	1,500
Total	**539,889**	*1,33,72,004*	*891,467*	**774,860**	*1,72,76,312*	*1,151,754*

Mica.

There was a decrease of about 1,000 cwts. in the declared output of mica in 1922 from that of the previous year. As has been frequently pointed out, the output figures are incomplete, and a better idea of the size of the industry is obtained from the export figures. The exports actually shew an increase of over 12,000 cwts., rising

from 30,944 cwts., valued at Rs. 63,94,113 (£426,274) in 1921, to 43,145 cwts., valued at Rs. 57,85,245 (£385,683) in 1922, corresponding to a fall in the average price per cwt. from Rs. 206·6 (£13·8) to Rs. 134·1 (£8·9).

TABLE 18.—*Quantity and value of Mica produced in India during 1921 and 1922.*

—	1921.			1922.		
	Quantity.	Value (Rupee=1*s.* 4*d.*)		Quantity.	Value (Rupee=1*s.* 4*d.*)	
	Cwts.	Rs.	£	Cwts.	Rs.	£
Bihar and Orissa—						
Gaya	5,013	1,77,473	11,832	15,975	1,40,803	9,387
Hazaribagh	20,746	10,82,535	72,169	13,420·8	9,08,680	60,579
Manbhum	4	60	4	..	..	..
Monghyr	201	7,597	506	5	90	6
Sambalpur	4	150	10	..	..	..
Central Provinces . . .	..	..	..	100	(*a*)	..
Madras—						
Kistna	8	499	33	..	..	..
Nellore	4,297	2,05,149	13,677	1,246·2	89,254	5,950
Nilgiris	14	1,696	113	55	6,227	415
Salem	20	1,595	106	..	..	..
Travancore	37	1,506	100	..	..	..
Mysore—						
Hassan	113	4,120	275	15·2	(*a*)	..
Mysore	69	153	10	120·5	(*a*)	..
Rajputana—						
Ajmer-Merwara . .	1,872	1,11,033	7,402	632·4	41,992	2,799
Total .	32,488	*15,93,560*	*106,237*	31,570·1	*11,87,046*	*79,136*

(*a*) Not available.

Monazite.

There was a further and larger decrease in the output of monazite in Travancore, which fell from 1,260 tons, valued at £30,959 in the previous year to 125 tons valued at £1,871 in 1922.

Petroleum.

In the review for the year 1920 it was necessary to record a decrease of 12½ million gallons in the output of petroleum from the production of 305,749,138 gallons recorded for the year 1919. In the year 1921 the total production almost equalled that of 1919, amounting to 305,683,227 gallons, important increases being recorded for the Singu and Yenangyaung fields; 1922, however, shews a decrease in output of over 7 million gallons, the total production being 298½ million gallons against the 305½ million gallons of 1921.

The Yenangyat field is rapidly dying; parts of it are already regarded as dead. The Singu and Yenangyaung oil-fields shew decided decrease where the outputs fell by 12 million gallons and 4½ million gallons respectively. A portion of the decrease in those two fields was balanced by the increased output in Thayetmyo, which rose from 66,000 gallons to 2⅓ million gallons. The remaining decrease in the Burma oilfields was to a great extent balanced by the enormous increase in the Attock oil-fields from a nominal figure of 59,000 gallons in 1921 to 7⅓ million gallons in the year under review. The Assam oil-fields maintained their output of the previous year. An attempt is now being made to utilize the shallow oil-sands of the Yenangyaung field which were shut off during the competitive rush for the richer deep sands; several remunerative wells are now being worked at depths a little above or below 400 feet. Another feature of this field is the electrification of the pumping plant which has now been applied to a large number of wells.

During the year active prospecting was continued in the Punjab, Assam, and Burma, by a variety of oil interests.

In the Punjab the oil industry entered on a new phase with the completion at Rawalpindi, and the opening, in February 1922, of the refinery erected by the Indo-Burma Petroleum Co. to deal with the production of the Khaur oilfield in the Attock district. The refinery has a daily capacity of 65,000 gallons of crude oil, but the throughput was considerably less than this during the year. The test wells in the Dhulian and Gabbir areas reached the depths of 2,551 feet and 1,646 feet respectively without striking oil in remunerative quantity; drilling in both areas is proceeding.

TABLE 19.—*Quantity and value of Petroleum produced in India during 1921 and 1922.*

—	1921.			1922.		
	Quantity.	Value (Rupee=1*s.* 4*d.*)		Quantity.	Value (Rupee=1*s.* 4*d.*)	
	Gals.	Rs.	£	Gals.	Rs.	£
Assam—						
Badarpur .	4,461,473	3,34,611	22,308	4,038,731	10,53,540	70,236
Digboi . .	5,069,461	2,50,833	16,722	5,343,910	2,64,412	17,627
Burma—						
Akyab . .	9,780	2,821	188	8,886	2,563	171
Kyaukpyu .	27,869	19,124	1,275	16,211	17,529	1,169
Minbu . .	3,706,831	11,58,385	77,226	3,940,416	12,31,380	82,092
Singu . .	104,167,749	2,92,97,179	1,953,145	92,107,998	3,45,73,653	2,304,910
Thayetmyo .	66,372	33,186	2,212	2,319,835	7,24,948	48,330
Upper Chindwin	1,182,782	2,95,695	19,713	1,210,914	90,818	6,055
Yenangyat .	2,510,533	7,84,541	52,303	2,413,416	7,54,192	50,279
Yenangyaung .	184,420,141	5,18,68,165	3,457,878	179,741,493	6,72,22,038	4,481,169
Punjab—						
Attock . .	59,306	14,826	988	7,362,315	18,40,579	122,705
Mianwali .	930	261	17	..	..	..
Total .	**305,683,227**	*8,40,59,627*	*5,603,975*	**298,504,125**	*10,77,75,652*	*7,185,043*

During the year, there was a considerable increase in the imports of kerosene oil, amounting to 11 million gallons, the increase being mostly in the imports from the United States of America, which exceeded the imports of the previous year by some 8½ million gallons. Out of the 2,560,139 gallons of kerosene oil shown against "other countries," about 2¼ million gallons came from Egypt.

During the year under review the export of paraffin wax decreased by 3,422 tons.

TABLE 20.—*Imports of Kerosene Oil during 1921 and 1922.*

—	1921.			1922.		
	Quantity.	Value (Rupee = 1s. 4d.).		Quantity.	Value (Rupee = 1s. 4d.).	
	Gals.	Rs.	£	Gals.	Rs.	£
From—						
Borneo .	8,179,354	43,81,022	292,068	7,245,454	36,75,965	245,064
Persia . .	236,374	1,77,280	11,819	..	..	..
Straits Settlements (including Labuan).	5,025	7,388	493	956,350	4,33,348	28,890
United States	34,441,518	2,73,50,225	1,823,348	43,088,869	3,22,16,428	2,147,762
Other countries	1,504	1,567	104	2,560,139	17,15,763	114,384
Total .	**42,863,775**	*3,19,17,482*	*2,127,832*	**53,850,812**	*3,80,41,504*	*2,536,100*

TABLE 21.—*Exports of Paraffin Wax from India during 1921 and 1922.*

—	1921.			1922.		
	Quantity.	Value (Rupee = 1s. 4d.)		Quantity.	Value (Rupee = 1s. 4d.).	
	Tons.	Rs.	£	Tons.	Rs.	£
To—						
Australia (including New Zealand).	1,791	8,18,957	54,597	2,143	8,72,960	58,197
China .	2,429	10,86,906	72,460	4,978	22,25,658	148,377
Egypt .	190	86,450	5,763	40	18,200	1,213
Italy . .	10,270	46,72,850	311,523	1,300	5,91,500	39,433
Japan .	3,814	17,35,256	115,684	8,319	37,62,285	250,819
Portuguese East Africa.	50	22,750	1,517	709	3,23,720	21,581
United Kingdom.	5,013	22,80,915	152,061	3,984	18,24,013	121,601
United States	1,134	5,15,970	34,398	1,250	5,68,750	37,917
Other countries.	6,367	28,89,303	192,620	4,913	22,21,991	148,133
Total .	**31,058**	*1,41,09,357*	*940,623*	**27,636**	*1,24,09,077*	*827,271*

Ruby, Sapphire and Spinel.

There was almost the same proportionate increase in the output of the ruby mines in 1922 as that recorded in the year 1921. The total production amounted to 231,160 carats, valued at Rs. 7,27,312 (£48,487), as against 193,915 carats, valued at Rs. 7,52,459 (£50,164) in 1921. It will be seen that, although the output increased, the total value decreased considerably. This is due to the decrease in the output of rubies which are more valuable than the sapphires and spinels; the outputs of the latter increased as much as to exceed the total figure of 1921 by over 37,000 carats.

TABLE 22.—*Quantity and value of Ruby, Sapphire and Spinel produced in India during 1921 and 1922.*

—	1921.			1922.		
	Quantity.	Value (Rupee = 1s. 4d.).		Quantity.	Value (Rupee = 1s. 4d.).	
	Carats.	Rs.	£	Carats.	Rs.	£
Burma—						
Mogok .	112,197 (Rubies).	6,91,200	46,080	93,078 (Rubies).	6,45,304	43,020
	48,916 (Sapphires)	57,232	3,816	102,462 (Sapphires)	76,045	5,070
	32,802 (Spinels).	4,027	268	35,620 (Spinels).	5,963	397
Total .	**193,915**	*7,52,459*	*50,164*	**231,160**	*7,27,312*	*48,487*

Salt.

There was an increase of 120,000 tons in the production of salt in 1922 over that of the preceding year. The production of Northern India increased by 126,000 tons, the decreases in Burma, Bombay and Sind being almost balanced by the increases in Aden and Madras. There was also an increase in the production of rock-salt from 148,038 tons in 1921 to 207,312 tons in 1922. The imports of salt slightly increased from 479,306 tons in 1921 to 507,073 tons in the year under review.

TABLE 23.—*Quantity and value of Salt produced in India during 1921 and 1922.*

—	1921.			1922.		
	Quantity.	Value (Rupee—1s. 4d.).		Quantity.	Value (Rupee=1s. 4d.).	
	Tons.	Rs.	£	Tons.	Rs.	£
Aden . . .	156,584	9,06,402	60,427	204,033	11,87,443	79,163
Bengal . .	35	1,160	77	3	106	7
Bombay and Sind	514,379	28,96,623	193,108	450,558	27,18,435	181,229
Burma . .	43,028	26,01,001	173,400	33,535	24,35,163	162,344·2
Central India* .	1	72	5	9·7	528	35·2
Gwalior* . .	159	7,585	506	210	10,007	667·1
Madras . .	446,113	26,22,460	174,831	465,929	29,43,066	196,204·4
Northern India .	373,184	20,87,279	139,152	499,386	29,81,926	198,795·1
Rajputana (Jaisalmer State)	196	9,615	641	234·5	11,596	773
Total .	**1,533,679**	*1,11,32,200*	*742,147*	**1,653,898·2**	*1,22,88,270*	*819,218*

*Figures relate to the official years 1921-22 and 1922-23.

TABLE 24.—*Quantity and value of Rock-Salt produced in India during 1921 and 1922.*

—	1921.			1922.		
	Quantity.	Value (Rupee=1s. 4d.).		Quantity.	Value (Rupee=1s. 4d.).	
	Tons.	Rs.	£	Tons.	Rs.	£
Salt Range .	123,084	5,98,823	39,922	183,533	9,36,785	62,452
Kohat .	19,635	48,969	3,265	18,904	56,444	3,763
Mandi . .	5,319	1,28,968	8,598	4,875	87,095	5,806
Total .	**148,038**	*7,76,760*	*51,785*	**207,312**	*10,80,324*	*72,021*

TABLE 25.—*Quantity and value of Salt imported into India during 1921 and 1922.*

	1921.			1922.		
	Quantity.	Value (Rupee = 1*s.* 4*d.*).		Quantity.	Value (Rupee = 1*s.* 4*d.*).	
	Tons.	Rs.	£	Tons.	Rs.	£
From—						
United Kingdom.	73,756	26,63,389	177,559	79,159	27,66,946	184,463
Germany	56,568	17,36,663	115,778	49,301	15,33,763	102,251
Spain	58,413	21,55,623	143,708	55,165	15,91,597	106,106
Aden and Dependencies.	142,044	44,94,987	299,666	165,777	50,11,039	334,069
Egypt	97,694	30,78,881	205,259	106,647	31,35,660	209,044
Italian East Africa.	50,765	16,58,724	110,581	50,989	17,14,338	114,289
Other countries	66	6,496	433	35	2,694	180
Total	**479,306**	*1,57,91,763*	*1,052,981*	**507,073**	*1,57,56,037*	1,050,402

Saltpetre.

In the total output of saltpetre, there was a decrease of over 4,000 tons in which all the provinces except the Punjab shared. The production of Bihar and the United Provinces decreased by 46 per cent. and 39 per cent. respectively, while the Punjab showed an increase of 16 per cent. The total Indian production amounted to 11,672·9 tons, valued at Rs. 35,22,995 (£234,866), against 15,893·7 tons valued at Rs. 53,55,478 (£357,032) in 1921. Exports decreased from about 13,000 tons in 1921 to 11,000 tons in the year under review, the decreases being shared by all the countries where exported, except Ceylon which alone shewed a considerable increase.

TABLE 26.—*Quantity and value of Saltpetre produced in India during 1921 and 1922.*

—	1921.			1922.		
	Quantity.	Value (Rupee=1s. 4d.).		Quantity.	Value (Rupee=1s. 4d.).	
	Tons.	Rs.	£	Tons.	Rs.	£
Bihar (refined)) .	4,277	13,96,264	93,084	2,009·1	5,05,494	33,700
Do. (*kuthea*) .	2,681	5,86,464	39,098	1,770	2,61,423	17,428
Central India .	1·7	450	30	15·8	3,780	252
Punjab . .	4,339	19,04,208	126,947	5,038·6	18,93,015	126,201
Rajputana .	229	82,752	5,517	182	46,487	3,099
United Provinces	4,366	13,85,340	92,356	2,657·4	8,12,796	54,186
Total .	**15,893·7**	*53,55,478*	*357,032*	**11,672·9**	*35,22,995*	*234,866*

TABLE 27.—*Distribution of Saltpetre exported during 1921 and 1922.*

—	1921.			1922.		
	Quantity.	Value (Rupee=1s. 4d.).		Quantity.	Value (Rupee=1s. 4d.).	
	Cwts.	Rs.	£	Cwts.	Rs.	£
To—						
Ceylon . .	16,376	2,25,403	15,027	62,003	7,49,349	49,956
Hongkong .	65,241	14,74,118	98,275	51,591	12,60,460	84,031
Japan . .	498	11,540	769	..	..	..
Mauritius and Dependencies.	59,464	10,46,876	69,792	26,225	4,59,461	30,631
United Kingdom.	88,294	15,10,773	100,718	50,898	7,42,310	49,487
United States of America.	15,002	2,32,580	15,505	4,362	61,438	4,096
Other countries	12,998	2,92,182	19,479	25,799	5,04,032	33,602
Total .	*257,873*	*47,93,472*	*319,565*	**220,878**	*37,77,050*	*251,803*

Silver.

There was a further increase in the output of silver from Bawdwin, which amounted to 4,205,584 ozs. against 3,555,021 ozs. in 1921. The production from the Kolar gold mines also increased. There was a slight decrease in the output from the Anantapur gold mines in Madras. The total Indian production was 4,244,304 ozs. valued at Rs. 1,01,28,504 (£675,234).

TABLE 28.—*Quantity and value of Silver produced in India during 1921 and 1922.*

—	1921.			1922.		
	Quantity.	Value (Rupee=1s. 4d.).		Quantity.	Value (Rupee=1s. 4d.).	
	Ozs.	Rs.	£	Ozs.	Rs. (a)	£
Burma— Northern Shan States.	3,555,021	88,20,855	588,057	4,205,584	1,00,39,362	669,291
Madras— Anantapur .	619	1,419	95	554	1,231	82
Mysore— Kolar . .	31,947	72,847	4,856	38,166	87,911	5,861
Total .	**3,587,587**	*88,95,121*	*593,008*	**4,244,304**	*1,01,28,504*	*675,234*

(*a*) Estimated.

Tin-ore.

There was a slight increase in the production of tin-ore amounting to 1,874·7 tons against 1,701·6 tons in 1921. The whole of the production was derived from Burma, Tavoy contributing 77 per cent. of the output and Mergui 22 per cent. Mergui also produced 217·8 tons of block tin, shewing a moderate increase over the figure for the previous year. The imports of unwrought tin decreased considerably from 53,114 cwts. in 1921 to 34,459 cwts. in 1922; 88 per cent. of these imports came from the Straits Settlements.

TABLE 29.—*Quantity and value of Tin and Tin-ore for the years 1921 and 1922.*

—	1921.						1922.					
	BLOCK TIN.			TIN-ORE.			BLOCK TIN.			TIN-ORE.		
	Quantity.	Value (Rupee=1s. 4d.).		Quantity.	Value (Rupee=1s 4d.).		Quantity.	Value (Rupee=1s. 4d.).		Quantity.	Value (Rupee=1s. 4d.).	
	Tons	Rs.	£	Tons	Rs.	£	Tons	Rs.	£	Tons	Rs.	£
Burma—												
Amherst . .	..	..	..	30·9	30,948	2,063	..	..	..	11·8	16,339	1,089
Mergui . .	171·2	4,62,104	30,807	409·9	5,95,306	39,687	217·8	5,33,395	35,560	407·6	5,87,184	39,146
Southern Shan States.	..	..	..	9·8	(a)	.	..	..	..	..	..	..
Tavoy . .	..	..	..	1,250	13,52,227	90,149	..	..	..	1,445	16,83,728	112,249
Thaton . .	..	..	..	1	960	64	.	..	..	10·3	13,790	919
Total .	171·2	*4,62,104*	*30,807*	1,701·6	*19,79,441*	*131,963*	217·8	*5,33,395*	*35,560*	1,874·7	*23,01,041*	*153,403*

(a) Figures not available.

TABLE 30.—*Imports of unwrought Tin, (block, ingots, slabs) into India during 1921 and 1922.*

—	1921.			1922.		
	Quantity.	Value (Rupee—1s. 4d.).		Quantity.	Value (Rupee—1s. 4d.).	
	Cwts.	Rs.	£	Cwts.	Rs.	£
From—						
United Kingdom.	2,148	3,05,230	20,349	3,242	3,90,077	26,005·1
Straits Settlements (including Labuan).	50,141	72,06,768	480,451	30,311	37,76,181	251,745·4
Other countries	825	1,13,417	7,561	906	1,09,461	7,297·4
Total .	**53,114**	*76,25,415*	*508,361*	**34,459**	*42,75,719*	*285,047·9*

Tungsten.

The production of wolfram increased slightly from 898·3 tons, valued at Rs. 4,39,388 (£29,292) during the previous year to 943 tons, valued at Rs. 3,75.532 (£25,035), in 1922. The increase in output was, however, accompanied by a decrease in total value, amounting to £1,257. The whole of the output with the exception of only 5 tons was derived from the Tavoy district. Recent experiments have found a use for tungsten carbide as a substitute for the "bort" used in the crowns of core-drills. The carbide is said to have a hardness very little inferior to "bort," and to be cheaper. As the price of "bort" is between £10 and £12 a carat, the substitution of tungsten carbide may add a much needed impetus to the wolfram-mining industry.

TABLE 31.—*Quantity and value of Tungsten-ore produced in India during 1921 and 1922.*

—	1921. (Rupee= 1s 4d.)			1922. (Rupee= 1s. 4d.)		
	Quantity.	Value.		Quantity.	Value.	
	Tons	Rs.	£	Tons	Rs.	£
Burma—						
Mergui .	4·9	1,597	106	4·75	4,274	285
Southern Shan States. .	7·4	(*a*)	(*a*)	..	..	..
Tavoy . .	886	4,37,791	29,186	938	3,71,048	24,736
Thaton . .	..	..	..	·25	210	14
Total .	**898·3**	*4,39,388*	*29,292*	**943·00**	3,75,532	25,035

(*a*) Not available.

Zinc.

18,061 tons of zinc ore were exported to Belgium during the year 1922 against 4,000 tons in the preceding year. The ore is found in association with galena in the Bawdwin mines leased by the Burma Corporation, Limited.

III.—MINERALS OF GROUP II.

Alum.

The production of alum rose from 3,380 cwts., valued at Rs. 64,400 (£4,293), in 1921 to 6,632 cwts., valued at Rs. 99,760 (£6,651) in the year under review. The whole output came from the Mianwali district in the Punjab.

Amber.

The production of amber amounted to only 3·6 cwts., valued at Rs. 1,960 (£131), in 1922, as against 26·3 cwts., valued at Rs. 16,840 (£1,123), in the preceding year.

Asbestos.

Of the total production of 242 tons of Asbestos, 228 tons came from the Hassan district in Mysore State, and the balance, 14 tons, from the district of Bhandara in the Central Provinces. The total value of the output was Rs. 10,520 (£701), consisting of 14 tons valued at Rs. 1,400 (£93) and 228 tons valued at Rs. 9,120 (£608).

TABLE 32.—*Production of Building Materials and Road-Metal in India during 1922.*

—	Granite and Gneiss.		Laterite.		Lime.		Limestone and Kankar.		Marble.		Sandstone.		Slate.		Trap.		Miscellaneous.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Assam	3,274	1,281	3,645	528		..	93,869	18,528	.	..	..	..	..	..	..	..	77,105	13,804
Baluchistan	..	..	..	.		..	2	(a)	..	..	..	..	..	..	..	..	..	..
Bihar and Orissa	1,478	226	602	19	35,410	15,300	436,709	53,256	..	..	10,785	1,296	2,665	2,804	990	205	64,675	5,221
Bombay	..	..	..				.	..	.	..	..	.	..	..	2,250	(a)	1,185	316
Burma	44,982	4,775	231,372	14,822	.	.	164,693	16,191	..	..	68,692	4,675	..	..	..	..	319,485	19,136
Central India	..	..	.	.	15,679	14,892	83,158	6,197	..	..	..	.	..	..	..	..	..	..
Central Provinces	..	..	.	.		..	161,367	25,888		..	..	..	..	..	..	..	..	..
Gwalior	..	..	.	.		.	2,684	782	..	..	12,114	3,205	.	..	..	..	..	..
Kashmir	..	..		.		..	.	..	26	(a)	..	..	..	..	..	..	..	..
Madras	16,785	380	150,028	4,524		.	20,065	4,822	..	..	..	..	108	14	..	..	313,124	12,359
Mysore	..	..	..		4,685	2,346	14,854	997	..	..	..	..	12	(a)	..	..	(b)1,600	133
N. W. F. Province	..	..	.	.	..	..	..	..	..	..	..	..	..	..	..	..	6,492	401
Punjab	..	..	.	..	.	..	39,513	2,305	.	..	..	..	35,600	7,739	..	..	91,640	4,997
Rajputana	..	..	..	..		.	33,639	3,148	3,833	9,524	55,607	15,179	200	67	..	..	127,037	21,573
United Provinces	..	..	..	.	..	..	126,161	11,282	..	..	..	..	1,200	444	..	..	1,342,463	69,252
Total	66,519	*6,662*	385,647	*19,893*	55,774	*32,538*	1,176,714	*143,396*	3,859	*9,524*	147,198	*24,355*	39,785	*11,068*	3,240	*205*	2,344,206	*147,192*

(a) Value not available.

(b) Excludes several thousands of cart loads of miscellaneous building materials and road metal, the weight of which is not known.

Barytes.

2,392·2 tons of barytes, valued at Rs. 48,000 (£3,200), were produced in 1922, against 1,691 tons, valued at Rs. 52,283 (£3,486), in 1921. 1,742·2 tons were reported from the Karnool district of the Madras Presidency, and 650 tons from the Alwar State, Rajputana.

Bauxite.

The output of bauxite in the Jubbulpore district rose from 1,999 tons, valued at Rs. 9,651 (£643), in 1921, to 3,987 tons, valued at Rs. 15,948 (£1,063), in the year under review. The mines at Kaira in Bombay, from which an output of 4,653 tons was reported in 1921, were not worked during the year 1922. Messrs. Dalchand Bahadur Singh of Calcutta, who were granted a prospecting license for bauxite in the Savantwadi State within the Bombay Presidency, obtained 932 tons of bauxite in the course of prospecting operations in 1922.

Building Materials and Road-metal.

The total estimated value of building stone and road-metal produced in the year under review was Rs. 59,22,498 (£391,833). (See Table 32). Certain returns supplied in cubic feet have been converted into tons on the basis of certain assumed relations between volume and weight.

Clay.

The recorded production of clay fell from 199,266 tons, valued at Rs. 5,60,664 (£37,378), in 1921, to 104,718 tons, valued at Rs. 2,73,272 (£18,218), in 1922.

TABLE 33.—*Production of Clays in India during 1922.*

—	Quantity.	Value (Rupee = 1s. 4d.)	
	Tons	Rs.	£
Bengal	13,307	14,877	992
Bihar and Orissa	8,475	1,56,699	10,447
Burma	21,048	24,667	1,644
Central India	18	45	3
Central Provinces	50,180	28,926	1,928
Gwalior	410	2,116	141
Madras	12	70	5
Mysore	2,943	29,430	1,962
Punjab	7,958	14,892	993
Rajputana	397	1,550	103
Total	**104,748**	*2,73,272*	*18,218*

Fuller's Earth.

There was a considerable rise in the production of Fuller's Earth, amounting to 13,539 tons, valued at Rs. 36,664 (£2,414), against 2,807 tons, valued at Rs. 14,490 (£966), in 1921.

TABLE 34.—*Production of Fuller's Earth in 1922.*

	Quantity.	Value (Rupee = 1s. 4d.)	
	Tons	Rs.	£
Central Provinces—			
Jubbulpore	152	748	50
Rajputana—			
Bikanir	1,387	7,356	490
Jodhpur	12,000	28,560	1,904
Total	**13,539**	*36,664*	*2,414*

Gypsum.

There was an increase of about 7,000 tons in the production of gypsum over that of 1921. The total production in 1922 amounted to 40,645·5 tons, valued at Rs. 64,479 (£4,298), against 33,801 tons, valued at Rs. 34,018 (£2,267), in the preceding year.

TABLE 35.—*Production of Gypsum during 1921 and 1922.*

	1921			1922		
	Quantity.	Value (Rupee = 1s. 4d.)		Quantity.	Value (Rupee = 1s. 4d.)	
	Tons	Rs.	£	Tons	Rs.	£
Kashmir	187	11,151	743	73·5	500	33
Punjab—						
Jhelum	5,329	4,663	311	7,801	6,825	455
Rajputana—						
Bikanir	16,285	13,204	880	28,371	45,154	3,010
Marwar	12,000	5,000	333	4,400	12,000	800
Total	**33,801**	*34,018*	*2,267*	**40,645·5**	*64,479*	*4,298*

Ilmenite. There was an output of 400 tons of ilmenite, valued at £1,200, at Muttam in the Travancore State, Madras Presidency.

Ochre. The total production of ochre in 1922 amounted to 6,702 tons, valued at Rs. 57,180 (£3,812), against 5,812·7 tons, valued at Rs. 32,606 (£2,174), excluding the amounts noted at foot of the following table :

TABLE 36.—*Production of Ochre during the years 1921 and 1922.*

—	1921			1922		
	Quantity.	Value (Rupee = 1s. 4*d*.).		Quantity.	Value (Rupee = 1s. 4*d*.).	
	Tons	Rs.	£	Tons	Rs.	£
Bihar and Orissa.	450	12,600	840	400	10,400	693
Central India .	3,877(*a*)	15,200	1,013·3	4,770·5	35,824	2,388·3
Central Provinces	221(*b*)	126	8·4	697	5,139	343
Gwalior . .	1,014·7	2,180	145·3	832	5,720	381·3
Kashmir . .	..	..	..	·5	7	·4
Mysore . .	250	2,500	167	..	..	..
Rajputana .	..	..	..	2	90	6
Total .	**5,812·7**	*32,606*	*2,174*	**6,702·0**	*57,180*	*3,812*

(*a*) Ochre (weight not reported) valued at Rs. 1,014 from Kothi and 2,000 tons of ochre (value not reported) from Bundelkhand not included.
(*b*) 60 tons of ochre (value not reported) from Chanda not included.

Soda. Twenty-eight tons of soda, valued at Rs. 1,021 (£68), were produced in the Ladak tahsil, Kashmir in 1922, against 10 tons, valued at Rs. 360 (£24), in 1921.

Steatite. The production of steatite fell from 2,070 tons, valued at Rs. 61,782 (£4,119), in 1921, to 906 tons valued at Rs. 36,395 (£2,426), in 1922.

TABLE 37.—*Quantity and value of Steatite produced in India during 1921 and 1922.*

—	1921			1922		
	Quantity	Value (Rupee = 1s. 4d.).		Quantity.	Value (Rupee= 1s. 4d.).	
	Tons.	Rs.	£	Tons.	Rs.	£
Bihar and Orissa—						
Bhagalpur .	90	900	60	..	...	...
Mayurbhanj .	62	3,850	257	71	6,900	460
Singhbhum .	27	3,356	224	·55	31	2
Burma—						
Pakokku Hill Tracts.	1·5	270	18	3·05	585	39
Central Provinces—						
Jubbulpore .	1,080	19,699	1,313	89·8	1,852	123
Madras—						
Nellore . .	40·5	5,866	391	70·4	3,969	265
Salem . .	528	13,987	932	542·6	14,298	953
Mysore . .	138	414	28	93·5	935	62
United Provinces—						
Hamirpur .	98	13,200	880	27	7,425	495
Jhansi . .	5	240	16	8	400	27
Total .	**2,070·0**	*61,782*	*4,119*	**905·90**	*36,395*	*2,426*

Zircon. 160 tons of zircon, valued at £1,280 were extracted from the Muttam mine in the Travancore State, Madras Presidency in 1922.

IV.—MINERAL CONCESSIONS GRANTED.

TABLE 38.—*Statement of Mineral Concessions granted during 1922.*

ASSAM.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Cachar .	(1) J. Blair, Esq., Bhanga Bazar, Sylhet.	Mineral oil . .	P. L. .	1,840·66	28th March 1922.	1 year.
Do. .	(2) The Amranagar Tea Syndicate.	Do. . .	P. L. .	1,036·80	13th May 1922.	Do.
Do. .	(3) The Budderpore Oil Co., Ltd.	Do. . .	P. L. .	1,388·80	1st November 1922.	Do.
Do. .	(4) The Burmah Oil Co., Ltd.	Do. . .	P. L. .	8,377·60	11th December 1922.	Do.
Lakhimpur	(5) Assam Oil Co., Ltd.	Oil . . .	P. L. .	5,120	30th March 1922.	Do.
Do. .	(6) Assam Railways and Trading Co., Ltd.	Coal, iron, slate, fire-clay and shale.	M. L. .	4,896	8th November 1922.	30 years.
Sibsagar .	(7) Assam Oil Co. .	Petroleum . .	P. L. .	1,440	20th March 1922.	1 year.
Do. .	(8) The Burmah Oil Co., Ltd.	Oil . . .	P. L. .	6,400	25th March 1922.	Do.
Do. .	(9) Do. .	Do. . . .	P. L. .	3,488	25th April 1922.	Do.
Sylhet .	(10) The Burmah Oil Co., Ltd.	Mineral oil . .	P. L. .	3,136	3rd May 1922	Do.

BALUCHISTAN.

Kalat .	(11) W. C. Clements .	Coal . . .	M. L. .	80	1st July 1922	30 years.
Do. .	(12) S. Gauhar Khan .	Do. . . .	M. L. .	218	Do.	Do.
Do. .	(13) The Burmah Oil Co., Ltd.	Oil . . .	P. L. .	3,200	1st September 1922.	1 year.
Sibi . .	(14) Seth Thikam Dass Girdhari Dass.	Coal . . .	M. L. .	160	1st July 1922	30 years.
Zhob . .	(15) The Baluchistan Chrome Co., Ltd.	Chromite . .	M. L. .	10	Do.	Do.
Do. .	(16) Do. .	Do. . .	M. L. .	10	Do.	Do.
Do. .	(17) Do. .	Do. . .	M. L. .	10	Do.	Do.
Do. .	(18) Do. .	Do. . .	M. L. .	10	Do.	Do.
Do. .	(19) Do. .	Do. . .	M. L. .	10	Do.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

BENGAL.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chittagong .	(20) Indo-Burma Petroleum Co., Ltd.	Mineral oil . .	P. L. .	3,082	17th March 1922.	1 year.
Chittagong Hill Tracts.	(21) Messrs. Bulloch Bros. & Co.	Do. . .	P. L. .	11,520	15th September 1922.	Do.
Do. .	(22) Do. .	Do. . .	P. L. .	24,960	Do.	Do.

BIHAR AND ORISSA.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Hazaribagh.	(23) Babu A. C. Sinha .	Mica . . .	P. L. .	40	29th January 1922.	1 year.
Do. .	(24) Babu Chhuttu Ram	Do. . . .	M. L. .	240	24th April 1922.	30 years.
Do. .	(25) Babu Kiran Sashi Chatterji.	Do. . . .	M. L. .	187	9th May 1922	Do.
Do. .	(26) Babu Bhujendra Nath Daw.	Do. . . .	P. L. .	40	20th June 1922.	1 year.
Do. .	(27) Babu Dwijendra Nath Mukharji.	Do. . . .	M. L. .	172·75	Not stated .	30 years.
Palamau .	(28) Messrs. Andrew Yule & Co., Managing Agents, Bengal Coal Co., Ltd.	Coal . . .	M. L. .	1,240	Do. .	Do.
Puri . .	(29) Mr. Thomas B. Lucas.	Red oxide of iron.	M. L. .	15 91	18th October 1922.	Do.
Sambalpur .	(30) Babu Debi Prasad Misra.	Mica . . .	P. L. .	280 57	2nd May 1922	1 year.
Do. .	(31) Babu Arjun Ladha.	Coal . . .	P. L. .	1,840 21	15th December 1922.	Do.
Santal Parganas.	(32) Babu Jetha Mulji .	Do. . . .	M. L. .	3	1st April 1922	Do.
Do. .	(33) Babu Bansi Ram Marwari.	Do. . . .	M. L. .	2·4	Do. .	Do.
Do. .	(34) Babu Ganga Ram Marwari.	Do. . . .	M. L. .	2·9	Do. .	Do.
Do. .	(35) Babu Bansi Ram Marwari.	Do. . . .	M. L. .	5·0	Do. .	Do.
Do. .	(36) Babu Ramrekh Marwari.	Do. . . .	M. L. .	5	1st April 1921	2 years.
Do. .	(37) Babu Bhudhar Chandra Dey.	Do. . . .	M. L. .	3·06	Do. .	Do.
Singhbhum.	(38) Babu Charu Chandra Mitra.	Chromite . .	M. L. .	41·42	Not stated	15 years.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

BURMA.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Akyab .	(39) Messrs. The Indo-Burma Petroleum Co., Ltd.	Mineral oil . .	P. L. . (renewal).	1,280	22nd April 1922.	2 years.
Do. .	(40) Maung Choon .	Do. . .	P. L. .	568·91	9th November 1922.	1 year.
Do. .	(41) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. . .	P. L. .	5,440	15th December 1921.	Do.
Amherst .	(42) Maung Ba Han .	All minerals (except oil).	M. L. .	1,038	22nd May 1920.	30 years.
Do. .	(43) Maung San Win .	Do. .	P. L. . (renewal).	640	1st December 1921.	1 year.
Do. .	(44) Maung San Maung and Maung Kywe.	Do. .	P. L. . (renewal).	1,824	17th December 1921.	Do.
Do. .	(45) A. C. Geewa . .	Do. .	P. L. . (renewal).	640	15th March 1922.	Do.
Do. .	(46) Mr. M. E. Moolla .	Do. .	P. L. .	527·87	25th May 1922.	Do
Do. .	(47) Saw Lein Lee .	Do. .	P. L. . (renewal).	348·16	5th April 1922	Do.
Do. .	(48) Maung Saw Maung and Ma Kywe.	Do. .	P. L. . (renewal).	640	21st March 1922.	Do.
Do. .	(49) Mr. A. C. Jeewa .	Do. . .	P. L. . (renewal).	640	8th May 1922	Do.
Do. .	(50) K. P. N. K. Narayanan Chetty.	Do. .	P. L. . (renewal).	2,240	11th June 1922.	Do.
Do. .	(51) Maung Ba Han .	Do. .	P. L. . (renewal).	1,920	21st June 1922.	Do.
Do. .	(52) Mr. K. E. I. Solomon.	Do. .	P. L. .	960	20th July 1922.	Do.
Do. .	(53) Messrs. Cookson & Co., Ltd.	Do. .	P. L. . (renewal).	319	23rd June 1922.	2 years.
Do. .	(54) Maung Choon .	Do. .	M. L. .	603·67	11th February 1921.	30 years
Do. .	(55) Maung Po Thine and Maung Po Kin.	All minerals (except oil).	P. L. . (renewal).	1,280	26th September 1922.	1 year.
Do. .	(56) Mr. K. P. N. K. Narayanan Chetty.	Do. .	P. L. . (renewal).	320	5th August 1922.	Do.
Do. .	(57) Mr. M. E. Moolla .	Mineral oil . .	P. L. . (renewal).	22,822·40	27th August 1922.	Do.
Do. .	(58) Saw Lein Lee . .	All minerals (except oil).	P. L. . (renewal).	640	1st November 1922.	Do.
Do. .	(59) Maung On Maung .	Do .	P. L. . (renewal).	1,280	5th December 1922.	Do.
Bhamo .	(60) Messrs. The Tavoy Tin Syndicate Ltd.	All minerals (except oil and jade)	P. L. . (renewal).	826·88	24th November 1922.	2 years

P. L.=*Prospecting License*. M. L.=*Mining Lease*.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Henzada .	(61) Mr. Lim Chin Tsong	Coal . . .	M. L. .	3,840	24th January 1922.	30 years.
Do. .	(62) Maung Kyi . .	Mineral oil .	P. L	1,280, 1,920, 1,920 & 1,280	Not stated .	1 year.
Do. .	(63) Messrs. Adamjee Hajee Dawood & Co.	Do. . .	P. L. .	6,400	28th November 1922.	Do.
Katha .	(64) Mr. W. R. Coleridge Beadon.	All minerals (except oil).	P. L. .	640	28th November 1921.	Do.
Do. .	(65) Ma Ma . .	Do. .	P. L. .	640	5th January 1922.	Do.
Do. .	(66) Messrs. Frank Johnson Sons & Co.	Do. .	P. L. .	5,248	23rd January 1922.	Do.
Do. .	(67) Ma Ma . . .	Do. .	P. L. (renewal).	1,600	21st February 1922.	Do.
Do. .	(68) Maung Pan Nyo .	Do. .	P. L. .	640	26th August 1922.	Do.
Do. .	(69) Do. .	Do. .	P. L. .	2,560	Do. .	Do.
Do. .	(70) Maung Shu Maung .	Do. .	P. L. (renewal).	960	10th August 1922.	Do.
Do. .	(71) Maung Po Hte .	Do. .	P. L. (renewal).	2,560	2nd October 1922.	Do.
Do. .	(72) Ma Ma . . .	Do. .	P. L. (renewal).	1,280	19th October 1922.	Do.
Kyaukpyu .	(73) Messrs. The Burmah Oil Co., Ltd.	Mineral oil . .	P. L. .	1,280	1st June 1922	Do.
Kyaukse .	(74) Maung Aung Ko .	All minerals (except oil).	P. L. .	2,351	6th June 1922	Do.
Do. .	(75) Do. .	Do. .	P. L. .	2,304	Do. .	Do.
Lower Chindwin.	(76) Mr. J. P. Harley .	Mineral oil . .	P. L .	7,040	27th March 1922.	Do.
Do. .	(77) Maung Po Kyan .	Do. . .	P. L. .	2,080	Do. .	Do.
Do. .	(78) Mr. Lawrence Dawson.	Do. . .	P. L (renewal)	3,008	7th February 1922.	Do.
Do. .	(79) Messrs. The Burmah Oil Co.	Do. .	P. L. (renewal).	640	23rd February 1922.	2 years.
Do. .	(80) Ma Ma . . .	Do. . .	P. L. .	2,956·80	5th July 1922	1 year.
Do. .	(81) Maung Ngwe Daing	All minerals including mineral oil.	P. L. .	1,920	24th July 1922.	Do.
Do. .	(82) Messrs. The Indo-Burma Petroleum Co., Ltd.	Mineral oil . .	P. L. .	8,576	23rd September 1922.	Do.
Do. .	(83) Do. .	Do. . .	P. L. .	6,400	11th September 1922.	Do.

P. L.=*Prospecting Licence.* M. L.=*Mining Lease.*

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Lower Chindwin.	(84) Ma Ma . . .	Mineral oil . .	P. L. .	4,774	14th October 1922.	1 year.
Do. .	(85) Messrs. The Indo-Burma Oil-Fields (1920) Ltd.	All minerals including mineral oil.	P. L. (renewal).	2,560	12th October 1922.	Do.
Do. .	(86) Do. .	Mineral oil . .	P. L. (renewal).	1,280	Do. .	Do.
Do. .	(87) Messrs. The Burma Finance and Mining Co., Ltd.	All minerals including mineral oil.	P. L. (renewal).	8,800	Do. .	Do.
Do. .	(88) Do. .	Do. .	P. L. (renewal).	9,440	Do. .	Do.
Magwe .	(89) Messrs. The Irrawaddy Petroleum Oil Syndicate.	Mineral oil . .	P. L. .	1,572·20	31st January 1922.	Do.
Do. .	(90) Mr. Colin Campbell.	Do. . .	P. L. .	2,720	11th January 1922.	Do.
Do. .	(91) Maung Kyan Baw .	Do. . .	P. L. .	1,240	2nd March 1922.	Do.
Do. .	(92) Mr. Abdul Rahman	Do. . .	P. L. .	3,840	16th January 1922.	Do.
Do. .	(93) Jaffer Ally Tar .	Do. . .	P. L. .	3,040	31st January 1922.	Do.
Do. .	(94) Maung Ba Than .	Do. . .	P. L. .	125·40	8th February 1922.	Do.
Do. .	(95) Maung Po San .	Do. . .	P. L. .	640	18th January 1922.	Do.
Do. .	(96) Do. .	Do. . .	P. L. .	640	20th February 1922.	Do.
Do. .	(97) Mr. A. E. Mayet .	Do. . .	P. L. .	1,280	7th April 1922.	Do.
Do. .	(98) Mr. E. E. Moolla .	Do. . .	P. L. .	100	16th April 1922.	Do.
Do. .	(99) Mr. Abdul Rahman	Do. . .	P. L. .	1,200	9th May 1922	Do.
Do. .	(100) Mr. E. E. Moolla .	Do. . .	P. L. (renewal).	100	19th May 1922.	Do.
Do. .	(101) Mr. W. H. Samuel	Do. . .	P. L. .	640	26th September 1922.	Do.
Do. .	(102) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. . .	P. L. .	7,680	21st July 1922.	Do.
Do. .	(103) Messrs. The Burmah Oil Co., Ltd.	Do. . .	P. L. .	1,200	19th August 1922.	Do.
Do. .	(104) Mr. Abdul Rahman	Do. . .	P. L. .	3,200	4th August 1922.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Magwe .	(105) Mr. Abdul Rahman	Mineral oil . .	P. L. .	1,440	12th July 1922.	1 year.
Do. .	(106) Do. .	Do. . .	P. L. .	640	19th August 1922.	Do.
Do. .	(107) Messrs. The Burmah Oil Co., Ltd.	Do. . .	P. L. (renewal).	3,840	2nd June 1922.	2 years.
Do. .	(108) Do. .	Do. . .	P. L. (renewal).	2,259·20	25th June 1922.	Do.
Do. .	(109) Messrs. The Union Oil Co., Ltd.	Do. . .	P. L. (renewal).	960	9th August 1922.	Do.
Do. .	(110) Maung Po Aung .	Petroleum . .	P. L. (renewal).	480·00	4th July 1922	1 year.
Do. .	(111) Maung Po San .	Do. . .	P. L. (renewal).	640	14th July 1922.	Do.
Do. .	(112) Messrs. The Union Oil Co., Ltd.	Do. . .	P. L. (renewal).	960	29th August 1922.	2 years.
Do. .	(113) Maung Aung Nyun	Gold . . .	P. L. (renewal).	300	21st August 1922.	1 year.
Do. .	(114) Mr. A. Rahman .	Petroleum . .	P. L. (renewal).	76	16th November 1922.	Do.
Mandalay .	(115) Maung Ba. U .	All minerals (except oil).	P. L. .	640	22nd May 1922.	Do.
Do. .	(116) Messrs. The Burma Corporation Ltd.	Iron-ore . .	P. L. (renewal).	640	6th June 1922	Do.
Meiktila .	(117) Messrs. The Coalfields of Burma.	Coal . . .	P. L. .	23,404·8	6th January 1922.	Do.
Do .	(118) Messrs. The Burmah Oil Co., Ltd.	Mineral oil . .	P. L. .	1,849·60	13th December 1922.	1 year.
Do. .	(119) Mr. Mahomed Ismail.	All minerals (except oil).	P. L. .	640	19th December 1922.	Do.
Mergui .	(120) Maung Po . .	Tin and allied minerals.	P. L. .	220·16	30th November 1921.	Do.
Do. .	(121) Messrs The Mergui Tin Dredging Co., Ltd.	All minerals (except oil).	P. L. .	204·80	5th December 1921	Do.
Do. .	(122) Mr. J. F. Leslie .	Do. .	M. L. .	798·72	18th August 1921.	30 years
Do. .	(123) Mr. F. G. Fitzherbert.	Tin and allied minerals.	P. L. .	261·12	22nd December 1921.	1 year.
Do. .	(124) Messrs. Wightman & Co., Ltd.	Tin . . .	P. L. .	15·00	24th November 1921.	Do.
Do. .	(125) Mr. J. T. Doupe .	Do. . . .	P. L. .	2,457·50	9th December 1921.	Do.
Do. .	(126) Do. .	Do. . . .	P. L. .	1,141·76	Do. . .	Do.
Do. .	(127) Do. .	Do. . . .	P. L. .	1,287·68	Do. .	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui .	(128) Mr. Jas. McGregor	Tin . . .	P. L. .	640·00	21st December 1921.	1 year.
Do. .	(129) Mr. Geo. W. Bowden. ..	All minerals (except oil).	P. L. .	1,267·20	19th December 1921.	Do.
Do. .	(130) Mr. A. S. Mahomed	Tin and other allied minerals.	P. L. .	704·00	21st December 1921 .	Do.
Do. .	(131) Mr. Geo. W. Bowden. .	All minerals (except oil).	P. L. .	1,428·73	Do. .	Do.
Do .	(132) Mr. A. S. Ahmed .	Tin and wolfram.	P. L. .	1,310·72	3rd January 1922.	Do.
Do. .	(133) Maung Po . .	Tin and allied minerals.	P. L. . (renewal).	665·60	4th December 1920.	Do.
Do. .	(134) Messrs. The Mergui Tin Dredging Co., Ltd.	Do. .	P. L. . (ronwal).	2,585·60	6th February 1921.	Do.
Do. .	(135) Lim Shain . .	Wolfram and tin and allied minerals.	P. L. . (renewal).	450·56	16th August 1921.	6 months .
Do. .	(136) Do. . .	Do. .	P. L. . (renewal).	665·60	1st August 1921.	1 year.
Do. .	(137) Mr. J. J. A. Page	All minerals (except oil).	P. L. . (renewal).	906·24	29th May 1921.	Do.
Do. .	(138) Messrs. The Burma Finance and Mining Co., Ltd.	Coal . . .	P. L. . (renewal).	3,947·52	16th August 1921.	Do.
Do. .	(139) Do. .	Do. . . .	P. L. . (renewal).	2,329·60	Do. .	Do.
Do. .	(140) Ba Chup . .	Tin . . .	P. L. . (renewal).	460·80	24th August 1921.	Do.
Do. .	(141) Mr. S. O. Holmes .	All minerals (except oil).	P. L. . (renewal).	942·08	14th July 1921.	Do.
Do. .	(142) Maung Choon .	Tin and allied minerals.	P. L. . (renewal).	25·37	23rd November 1921.	6 months.
Do. .	(143) Messrs. Wightman & Co., Ltd.	Tin . . .	P. L. .	11·5	9th December 1921.	1 year.
Do. .	(144) Messrs. Morgan & Holmes.	All minerals (except oil).	P. L. .	517·12	Do. .	Do.
Do. .	(145) Mr. Teoh Teik Hoo	Tin-ore . .	P. L. .	2,570·24	15th June 1922.	Do.
Do. .	(146) Messrs. The Indian Mines Development Syndicate Ltd.	All minerals (except oil).	P. L. .	902·56	23rd March 1922.	Do.
Do. .	(147) Mr. M. Hanif .	Wolfram and tin .	M. L .	294·36	25th March 1920.	30 years.
Do. .	(148) Miss S. M. G. Penny.	Tin . . .	P. L. .	1,841·49	20th July 1922.	1year.
Do. .	(149) Mr. M. Hanif .	Wolfram and tin	M. L. .	983·32	23rd November 1920.	30 years.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui .	(150) Maung Po Thaik and Wee Tein.	Tin . . .	P. L. .	2,099·20	10th July 1922	1 year.
Do. .	(151) Mr. Joo Seng .	All minerals (except oil).	P. L. .	2,268·16	29th April 1922.	Do.
Do. .	(152) Mr. G. H. Hand .	Tin and allied minerals.	P. L. .	640	10th June 1922.	Do.
Do. .	(153) Mr. Geo. W. Bowden.	All minerals (except oil).	P. L. .	634·88	5th June 1922.	Do.
Do. .	(154) Mr. S. O. Holmes .	Do. .	P. L. .	624·64	7th March 1922.	Do.
Do. .	(155) Mr. M. Esoof Bhymeah.	Do.	P. L. . (renewal).	817·41	12th August 1922.	Till the mining lease is sanctioned.
Do. .	(156) Maung San Dun .	Tin and allied minerals.	P. L. . (renewal).	568·32	14th December 1921.	1 year.
Do	(157) Maung Po Thaik .	Tin and Wolfram	P. L. . (renewal).	486·40	12th January 1922.	Do.
Do.	(158) Mr. S. O. Holmes	All minerals (except oil).	P. L. . (renewal).	327·68	1st April 1922.	Do.
Do.	(159) Maung Po . .	Tin and allied minerals.	P. L. . (renewal).	793·60	29th October 1920.	Till the mining lease is sanctioned.
Do. .	(160) Aung Sein Swai .	All minerals (except oil).	P. L. . (renewal).	2,088·96	12th January 1922.	Do.
Do. .	(161) Mr. S. O. Holmes .	Do. .	P. L. . (renewal).	614·63	22nd March 1922.	1 year.
Do. .	(162) Mr. A. S. Mahomed	Tin, wolfram and allied minerals.	P. L. . (renewal).	3,008	12th March 1922.	Till the mining lease is sanctioned.
Do. .	(163) Mr. W. H. Slivant	Tin and tungsten.	P. L. . (renewal).	517·12	26th September 1921.	Do.
Do. .	(164) Mr. J. J. A. Page .	Cassiterite .	P. L. .	1,940·48	28th November 1922.	1 year.
Do. .	(165) Mr. Joo Seng .	Tin-ore . .	P. L. .	752·64	Do. .	Do.
Do. .	(166) Mr. B. B. Jubb .	Do. . .	P. L. .	1,469·44	30th November 1922.	Do.
Do. .	(167) Messrs. The Indian Mines Development Syndicate Ltd.	Do. . .	P. L. .	1,310·72	16th October 1922.	Do.
Do. .	(168) Do. .	Do. . .	P. L. .	496·64	2nd October 1922.	Do.
Do. .	(169) Do. .	Do. . .	P. L. .	450·56	Do. .	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui .	(170) Maung Kyin Bu .	Tin . . .	P. L. (renewal).	349·44	5th February 1921.	Till the mining lease is sanctioned.
Do. .	(171) Mr. Lim Shain .	Wolfram, tin and allied minerals.	P. L. (renewal).	450·60	16th February 1922.	Do.
Do. .	(172) Messrs. The Burma Finance and Mining Co., Ltd.	Coal . . .	P. L. (renewal).	1,409·60	6th January 1922.	1 year.
Do. .	(173) Maung Po Thaik .	Tin . . .	P. L. (renewal).	66·56	10th June 1922.	6 months or till the mining lease is sanctioned.
Do. .	(174) Mr. Charles Kitchen	All minerals (except oil).	P. L. (renewal).	716·80	27th May 1922.	1 year.
Do. .	(175) Mr. T. Greenhow .	Tin and wolfram .	P. L. (renewal).	4,597·76	14th July 1922.	Till the mining lease is sanctioned.
Do. .	(176) Mr. A. E. Ahmed .	Wolfram, tin and allied minerals.	P. L. (renewal).	844·80	15th September 1922.	1 year.
Minbu .	(177) Sir S. K. Osmani .	Mineral oil . .	P. L. .	1,280	21st September 1921.	Do.
Do. .	(178) Messrs. The Burmah Oil Co., Ltd.	Do. . .	P. L. .	640 (Western halves of demarcated blocks 13S and 15S in Minbu Oil fields).	29th April 1922.	Do.
Do. .	(179) Mr. D. M. Akhoon.	Do. . .	P. L. .	320 (Western half of demarcated block 11S in Minbu Oil field).	23rd December 1921.	Do.
Do. .	(180) Do. .	Do. . .	P. L. .	1,280	18th May 1922.	Do.
Do. .	(181) Messrs. The Burma Finance and Mining Co., Ltd.	All minerals including mineral oil.	P. L. .	1,920	23rd December 1921.	Do.
Do. .	(182) Messrs. The Union Oil Co. of Burma, Ltd.	Mineral oil . .	P. L. (renewal).	2,655	17th February 1922.	2 years.
Do. .	(183) Messrs. The Irrawaddy Petroleum Oil Syndicate, Ltd.	Do. . .	P. L. (renewal).	640 (Block 16S in Minbu Oil field).	5th March 1922.	Do.
Do. .	(184) Messrs. The Burma Finance and Mining Co., Ltd.	Do. . .	P. L. .	3,200	1st September 1922.	1 year.

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BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Minbu .	(185) Maung Thit .	Mineral oil . .	P. L. .	2,560	31st October 1922.	1 year.
Myingyan .	(186) Mr. Baijnath Singh	Do. . .	P. L. .	3,200	16th June 1922.	Do.
Do. .	(187) Maung Kyaw Zan U.	All minerals including mineral oil.	P. L. .	1,909·80	27th May 1922.	Do.
Do. .	(188) Messrs. Frank Johnson Sons & Co., Ltd.	Mineral oil . .	P. L. (renewal).	2,035·20	27th July 1922.	Do.
Do. .	(189) Messrs. The Burmah Oil Co., Ltd.	Do. . .	P. L. .	1,004·80	31st July 1922.	Do.
Do. .	(190) Do. .	Do. . .	P. L. (renewal).	2,960	5th July 1922	2 years.
Do. .	(191) Do. .	Do. . .	P. L. (renewal).	4,107·52	27th July 1922.	Do.
Do. .	(192) Do. .	Do. . .	P. L. (renewal).	1,158·40	17th September 1922.	Do.
Myitkyina .	(193) Mr. R. C. J. Swinhoe.	Silver and copper.	P. L. .	640	1st September 1922.	1 year.
Northern Shan States.	(194) Messrs. The Burma Corporation, Ltd.	Iron-ore . .	P. L. .	160	27th February 1922.	Do.
Pakokku .	(195) Messrs. The Nath Singh Oil Co.	Mineral oil . .	P. L. (renewal).	14,400	27th November 1921.	Do.
Do. .	(196) Maung Po Thi .	Do. . .	P. L. (renewal).	640	17th November 1921.	Do.
Do. .	(197) Maung Kyaw .	Do. . .	P. L. (renewal).	80 acres in eastern portion of Block 34.	6th November 1921.	2 years.
Do. .	(198) Maung Pya Hta .	Do. . .	P. L. .	220 acres in Block 35.	30th March 1922.	1 year.
Do. .	(199) Mr. Baijnath Singh	Do. . .	P. L. (renewal).	1,120	28th March 1922.	Do.
Do. .	(200) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. . .	P. L. (renewal).	800	4th February 1922.	Do.
Do. .	(201) Messrs. The British Burma Petroleum Co., Ltd.	Do. . .	P. L. .	960	16th May 1922.	Do.
Do. .	(202) Messrs. The Rangoon Oil Co., Ltd.	Do. . .	P. L. .	1,068·80	19th May 1922.	Do.
Do. .	(203) Do. .	Do. . .	P. L. .	624	Do. .	Do.
Do. .	(204) Messrs. The Nath Singh Oil Co.	Do. . .	P. L. (renewal)	2,240	24th March 1922.	One to two years.

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BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Pakokku .	(205) Mr. Baijnath Singh	Mineral oil . .	P. L. (renewal).	3,840 308·5	18th June 1922.	1 year.
Do. .	(206) Ma Zan . .	Do. . .	P. L. (renewal).	100 acres in Blocks 160 and 39.	30th June 1922.	Do.
Do. .	(207) Messrs. The British Burma Petroleum Co., Ltd.	Do. . .	M. L. .	640	16th August 1919.	30 years.
Do. .	(208) Mr. Suleman .	Do. . .	P. L. .	640	28th October 1922.	1 year.
Do. .	(209) Maung Po Thi .	Do. . .	P. L. (renewal).	640	17th November 1922.	Do.
Prome .	(210) Mr. H. P. Cameron	Do. . .	P. L. .	3,258·63	30th March 1922.	Do.
Do. .	(211) Mr. Golabery Govindram.	Do. . .	P. L. .	110·08	22nd March 1922.	Do.
Do. .	(212) Maung Bo Ni .	Do. . .	P. L. .	640	28th March 1922.	Do.
Do. .	(213) Mr. Su Kwin Ping	Do. . .	P. L. (renewal).	267·52	18th September 1921.	Do.
Do. .	(214) Maung Shwe Bwa.	Do. . .	P. L. .	159	25th May 1922.	Do.
Do. .	(215) Do. .	Do. . .	P. L. .	640	Do. .	Do.
Do. .	(216) Maung Shwe Yan .	Do. . .	P. L. .	471·04	29th May 1922.	Do.
Do. .	(217) Do. .	Do. . .	P. L. .	640	Do. .	Do.
Do. .	(218) Miss Asha Bibi .	Do. .	P. L. .	1,600	17th June 1922.	Do.
Do. .	(219) Mr. G. R. Wells .	Do. . .	P. L. .	102·40	3rd July 1922	Do.
Do. .	(220) Mr. Golabory Govindram.	Do. . .	P. L. .	1,920	15th September 1922.	Do.
Shwebo .	(221) Ko Ko Gyi . .	All minerals (except oil).	P. L. (renewal).	640	23rd December 1921.	2 years.
Do. .	(222) Messrs. The Indo-Burma Petroleum Co., Ltd.	Mineral oil . .	P. L. (renewal).	8,424	5th November 1921.	Do.
Do. .	(223) Do. .	Do. . .	P. L. .	1,280	31st July 1922.	1 year.
Do. .	(224) Messrs. Frank Johnson Sons & Co., Ltd.	All minerals (except oil).	P. L. (renewal).	1,920	18th February 1922.	Do.
Do. .	(225) Messrs. The Burmah Oil Co., Ltd.	Mineral oil . .	P. L. .	2,880	14th August 1922.	Do.
Do. .	(226) Maung Pe Than .	All minerals (except oil).	P. L. .	1,920	21st September 1922.	Do.

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BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Shwebo .	(227) Messrs. The Burmah Oil Co., Ltd .	Mineral oil . .	P. L. . (renewal).	4,160	19th April 1922	2 years.
Do. .	(228) Do. .	Do. . .	P. L. . (renewal).	7,993·60	Do. .	Do.
Do. .	(229) Tan Ba Thwin .	Do. . .	P. L. . (renewal).	100	31st March 1922.	1 year.
Do. .	(230) Messrs. Balthazar & Son.	Do. . .	P. L. .	17,920	17th October 1922.	Do.
Do. .	(231) Ko Ko Gyi . .	All minerals (except oil).	P. L. .	1,920	3rd October 1922.	Do.
Do. .	(232) Maung Pe Thon & Maung Kin Myint.	Do. .	P. L. .	1,920	21st September 1922.	Do.
Do. .	(233) Ma Mya and Maung Po Oh.	Coal . .	P. L. .	960	11th November 1922.	Do.
Southern Shan States. .	(234) Messrs. The Burma Shan Co.	Gold, copper and other associated minerals.	P. L. .	5,440	15th March 1922.	Do.
Do. .	(235) Do. .	Gold and other minerals.	P. L. .	640	Do. .	Do.
Do. .	(236) Messrs. The Coalfields of Burma Ltd.	Coal . . .	P. L. .	84,326·4	28th March 1922.	Do.
Do. .	(237) Messrs. Frank Johnson Sons & Co.	All minerals (except oil).	P. L. .	640	16th February 1922.	Do.
Do. .	(238) Messrs. Su Kwin Ping & Co.	Red, yellow ochre and black earth.	P. L. .	640	1st April 1922.	Do.
Do. .	(239) Maung Yaung .	All minerals (except oil).	P. L. . (renewal)	2,400	10th June 1922 .	Do.
Do. .	(240) Messrs. U Myaing Daw Mi & Sons.	Antimony . .	P. L. . (renewal).	160	26th June 1922.	Do.
Do. .	(241) Messrs. Steel Bros. & Co.	All minerals (except oil).	P. L. .	18,153	10th April 1922.	Do.
Do. .	(242) Kengtung Sawbwa	Mineral oil . .	P. L. .	2,560	15th August 1922.	Do.
Do. .	(243) Do. .	Do. . .	P. L. .	2,560	Do. .	Do.
Tavoy .	(244) Mr. G. Lovell .	All minerals (except oil).	P. L. .	123	13th January 1922.	Do.
Do. .	(245) Quah Cheng Guan	Do. .	P. L. .	586	14th February 1922.	Do.
Do. .	(246) Khoo Tun Byan .	Do. .	P. L. .	551	16th February 1922.	Do.
Do. .	(247) Mr. G. Lovell .	Do. .	P. L. . (renewal).	195	21st April 1921.	Do.
Do. .	(248) Quah Cheng Tock	Do. .	P. L. . (renewal).	657	24th October 1921.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy .	(249) Mr. R. C. N. Twite	All minerals (except oil).	P. L. (renewal).	574	13th December 1921.	1 year.
Do. .	(250) Do. .	Do. .	P. L. (renewal).	589	13th February 1922.	Do.
Do. .	(251) Ong Hoe Kyin .	Do. .	P. L. (renewal).	614	28th February 1922.	6 months.
Do. .	(252) Mr. G. Willison .	Do. .	P. L. .	640	5th May 1922	1 year.
Do. .	(253) Mr. J. J. A. Page .	Do. .	P. L. .	210	26th April 1922.	Do.
Do. .	(254) Maung Ba Oh .	Do. .	P. L. .	632	23rd June 1922.	Do.
Do. .	(255) Mr. M. Manekjee .	Do. .	P. L. (renewal).	1,664	1st October 1921.	Do.
Do. .	(256) Mr. W. C. Toms .	Do. .	P. L. (renewal).	684	15th March 1922.	Do.
Do. .	(257) Maung Maung .	Do. .	P. L. (renewal)	256	20th April 1922.	6 months.
Do. .	(258) Mr. T. Fowle .	Do. .	P. L. (renewal).	307	4th May 1922	1 year.
Do. .	(259) Mr. G. Lovell .	Do. .	P. L. .	317	17th August 1922.	Do.
Do. .	260) Maung Ni Toe .	Do. .	P. L. .	116	31st July 1921.	Do.
Do. .	(261) Maung Ba Oh .	Do. .	M. L. .	688·87	4th April 1920.	30 years.
Do. .	(262) Quah Cheng Guan.	Do. .	P. L. (renewal).	253	25th April 1922.	1 year.
Do. .	(263) Messrs. J. A. Ali Bros.	Do. .	P. L. (renewal).	236	30th May 1922.	Do.
Do. .	(264) Mr. J. J. A. Page .	Do. .	P. L. (renewal).	338	21st July 1922.	2 years.
Do. .	(265) Mr. G. Willison .	Tin and wolfram	P. L. .	520	11th December 1922	1 year.
Do. .	(266) Maung Po Myee .	All minerals (except oil).	P. L. .	570	18th December 1922.	6 months.
Do. .	(267) Mr. W. C. Toms .	Do. .	P. L. .	635	24th November 1922.	1 year.
Tharrawaddy .	(268) Maung Aung Nyun	Mineral oil . .	P. L. .	640	22nd December 1922.	Do.
Thaton .	(269) Maung Pu . .	Tin	P. L. .	505·6	2nd February 1922.	Do.
Do. .	(270) Ma Thein Zin .	All minerals (except oil).	M. L. .	235·24	14th April 1921.	30 years.
Do. .	(271) Maung Pu . .	Tin and wolfram .	P. L. (renewal).	1,260·80	10th September 1922	1 year.

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BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Thaton .	(272) Ma Bwa . .	Tin and wolfram.	P. L. (renewal).	2,060·80	20th September 1922.	2 years.
Thayetmyo.	(273) Omar Abu Bucker	Mineral oil . .	P. L. .	5,760	7th November 1921.	1 year.
Do. .	(274) Messrs. The Indo-Burma Oil-fields (1920) Ltd.	Do. . .	P. L. .	7,072	23rd January 1922.	Do.
Do. .	(275) Do. .	Do. . .	P. L. .	2,560	14th December 1921.	Do.
Do. .	(276) Messrs. Mahomed Esoof Bhymeah & Co.	Do. . .	P. L. .	2,560	12th January 1922.	Do.
Do. .	(277) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. . .	P. L. .	4,480	8th August 1922.	Do.
Do. .	(278) Messrs. The Indo-Burma Oil-fields (1920) Ltd.	Coal . . .	P. L. .	448	27th June 1922.	Do.
Do. .	(279) Maung Tun Aung Gyaw.	Mineral oil . .	P. L. (renewal).	100	4th July 1922	Do.
Do. .	(280) Messrs. The Union Oil Co., of Burma, Ltd.	Do. . .	P. L. .	3,712	15th September 1922.	Do.
Do. .	(281) Do. .	Do. . .	P. L. .	2,662·40	20th September 1922.	Do.
Do. .	(282) Do. .	Do. . .	P. L. .	2,880	6th November 1922.	Do.
Do. .	(283) Mr. Golabory Govindram.	Do. . .	P. L. .	640	29th September 1922.	Do.
Do. .	(284) Do. .	Do. . .	P. L. .	640	4th November 1922.	Do.
Upper Chindwin.	(285) Mr. Rawland Ady.	Do. . .	P. L. .	2,656	23rd February 1922.	Do.
Do. .	(286) Messrs. Frank Johnson Sons & Co., Ltd.	Do. . .	P. L. .	2,250	18th January 1922.	Do.
Do. .	(287) Do. .	Oil and coal .	P. L. .	2,540	18th April 1922.	Do.
Do. .	(288) Messrs. The Indo-Burma Petroleum Co., Ltd.	Mineral oil . .	P. L. (renewal).	12,800	12th September 1921.	Do.
Do. .	(289) Messrs. Frank Johnson Sons & Co.	Do. . .	P. L. .	2,560	26th July 1922.	Do.
Do. .	(290) Mr. W. R. Smith .	Gold . . .	P. L. .	1,196·80	26th August 1922.	Do.
Do. .	(291) Messrs. The Indo-Burma Petroleum Co., Ltd.	Mineral oil . .	P. L. (renewal).	2,560	29th April 1922.	Do.

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BURMA—*concld.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Upper Chindwin.	(292) Messrs. The Indo-Burma Petroleum Co., Ltd.	Mineral oil . .	P. L. (renewal).	3,200	24th May 1922.	1 year.
Do. .	(293) Messrs. Frank Johnson Sons & Co., Ltd.	Mineral oil and coal.	P. L. (renewal).	1,824	7th February 1922.	Do.
Do. .	(294) Messrs. The Indo-Burma Petroleum Co., Ltd.	Mineral oil . .	P. L. (renewal).	3,840	16th May 1922.	2 years.
Yamethin .	(295) Mr. Li Ah Lye .	All minerals (except oil).	P. L. (renewal).	1,100·8	4th August 1922.	1 year.
Do. .	(296) Maung Kyaw Zan U.	Petroleum . .	P. L. .	3,200	7th August 1922.	Do.

CENTRAL PROVINCES.

Balaghat .	(297) Messrs. Tata Sons, Ltd.	Bauxite . .	P. L. (renewal).	533	1st February 1922.	1 year.
Do. .	(298) Do. .	Do. . .	P. L. (renewal).	325	Do. .	Do.
Do. .	(299) Do. .	Do. . .	P. L. (renewal).	65	Do. .	Do.
Do. .	(300) Do. .	Do. . .	P. L (renewal.)	64	Do. .	Do.
Do. .	(301) Do. .	Do. . .	P. L. (renewal).	267	Do.	Do.
Do. .	(302) Do. .	Do. . .	P. L. (renewal).	151	Do. .	Do.
Do. .	(303) Do. .	Do. . .	P. L. (renewal).	20	Do. .	Do.
Do. .	(304) Do. .	Do. . .	P. L. (renewal).	46	Do. .	Do.
Do. .	(305) Do. .	Do. . .	P. L. (renewal).	93	Do. .	Do.
Do. .	(306) Mr. B. N. Soparkar	Manganese . .	P. L. (renewal).	133	16th February 1922.	Do.
Do. .	(307) Do. .	Do. . .	P. L. (renewal).	278	Do. .	Do.
Do. .	(308) Do. .	Do. . .	P. L. .	38	18th February 1922.	Do.
Do. .	(309) Do. .	Do. . .	P. L. .	84	Do. .	Do.
Do. .	(310) Do. .	Do. . .	P. L. .	141	Do. .	Do.
Do. .	(311) Mr. M. A. Pasha, Minor, Guardian Shaikh Alimuddin.	Do. . .	P. L. .	92	3rd February 1922.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(312) Mr. C. S. Harris .	Manganese . .	P. L. .	25	3rd February 1922.	1 year.
Do. .	(313) R. S. Chajjoo Ram	Do. . .	P. L. .	111	13th February 1922.	Do.
Do. .	(314) Do. .	Do. . .	P. L. .	42	Do. .	Do.
Do. .	(315) Seth Shriram .	Do. . .	M. L. .	900	30th March 1922.	10 years.
Do. .	(316) Lala Debiprasad Beharilal.	Do. . .	M. L. .	3	10th March 1922.	5 years.
Do. .	(317) Messrs. Tata & Sons, Ltd.	Bauxite . .	P. L. (renewal.)	28	27th June 1922.	1 year.
Do. .	(318) Seth Shriram .	Manganese . .	P. L. (renewal.)	56	8th May 1922	Do.
Do. .	(319) R. B. Bansilal Abirchand Mining Syndicate.	Copper . .	P. L. (renewal)	532	31st August 1922.	Do.
Do. .	(320) Messrs. Martin & Co.	Manganese . .	P. L. .	272	4th May 1922	Do.
Do. .	(321) Pandit Rewashanker.	Do. . .	M. L. .	72	11th April 1922.	15 years.
Do. .	(322) Do .	Do. . .	M. L. .	49	Do. .	10 years.
Do. .	(323) The Central India Mining Co.	Do. . .	M. L. .	6	5th May 1922	15 years.
Do. .	(324) Messrs. B. B. Fouzdar Bros.	Iron-ore . .	P. L. .	15	29th June 1922.	1 year.
Do. .	(325) K. B. B. P. Byramji & Co.	Manganese . .	P. L. .	23	Do. .	Do.
Do. .	(326) Messrs. Tata Sons, Ltd.	Bauxite . .	P. L. (renewal)	56	20th May 1922.	Do.
Do. .	(327) Do. .	Do. . .	P. L. (renewal)	44	Do. .	Do.
Do. .	(328) Do. .	Do. . .	P. L. (renewal)	412	Do. .	Do.
Do. .	(329) Do. .	Do. . .	P. L. (renewal.)	27	Do. .	Do.
Do. .	(330) Do. .	Do. . .	P. L. (renewal.)	118	Do. .	Do.
Do. .	(331) Do. .	Do. . .	P. L. (renewal.)	187	Do. .	Do.
Do. .	(332) Do. .	Do. . .	P. L. (renewal.)	781	4th May 1922	Do.
Do. .	(333) Do. .	Do. . .	P. L. (renewal.)	49	6th May 1922	Do.
Do. .	(334) Do. .	Do. . .	P. L. (renewal.)	16 .	Do. .	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(335) Messrs. Tata Sons, Ltd.	Bauxite . .	P. L. (renewal.)	1,365	27th August 1921.	1 year.
Do. .	(336) Do. .	Do. . .	P. L. (renewal.)	469	1st August 1922.	Do.
Do. .	(337) Do. .	Do. . .	P. L. (renewal.)	187	Do. .	Do.
Do. .	(338) Do. .	Do. . .	P. L. (renewal.)	49	Do. .	Do.
Do. .	(339) Do. .	Do. . .	P. L. (renewal.)	187	Do. .	Do
Do. .	(340) Do. .	Do. . .	P. L. (renewal.)	77	Do. .	Do.
Do. .	(341) Do. .	Do. . .	P. L. (renewal.)	397	2nd August 1922.	Do.
Do. .	(342) Do. .	Do. . .	P. L. (renewal.)	628	Do. .	Do.
Do. .	(343) Do. .	Do. . .	P. L. (renewal.)	452	Do. .	Do.
Do. .	(344) Do. .	Do. . .	P. L. (renewal.)	242	Do. .	Do.
Do. .	(345) Do. .	Do. . .	P. L. (renewal.)	650	Do. .	Do.
Do. .	(346) Do. .	Do. . .	P. L. (renewal.)	964	Do. .	Do.
Do. .	(347) Do. .	Do. . .	P. L. (renewal.)	124	Do. .	Do.
Do. .	(348) Do. .	Do. . .	P. L. (renewal.)	91	Do. .	Do.
Do. .	(349) Do. .	Do. . .	P. L. (renewal.)	316	Do. .	Do.
Do. .	(350) Do. .	Do. . .	P. L. (renewal.)	7,187	Do. .	Do.
Do. .	(351) Do. .	Do. . .	P. L. (renewal.)	119	Do. .	Do.
Do. .	(352) Do. .	Do. . .	P. L. (renewal.)	188	Do. .	Do.
Do. .	(353) Do. .	Do. . .	P. L. (renewal.)	125	Do. .	Do.
Do. .	(354) Balkrishna Narayan Soparkar.	Manganese . .	P. L. (renewal.)	27	15th August 1922.	Do.
Do. .	(355) Do. .	Do. . .	P. L. (renewal.)	22	25th July 1922.	Do.
Do. .	(356) Do. .	Do. . .	P. L. (renewal.)	19	29th September 1922.	Do.
Do. .	(357) Rai Bahadur Bissessardas Daga.	Do. . .	M. L. .	85	25th September 1922.	5 years.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(358) Seth Permanand Sorapchand.	Bauxite . .	P. L. .	49	8th July 1922	1 year.
Do. .	(359) Do. .	Do. . .	P. L. .	58	Do. .	Do.
Do. .	(360) Do. .	Do. . .	P. L. .	1,293	Do. .	Do.
Do. .	(361) Do. .	Do. . .	P. L. .	105	Do. .	Do.
Do. .	(362) Mr. Bakaram Singh	Do. . .	P. L. .	6	25th July 1922.	Do.
Do. .	(363) Khan Bahadur B. P. Byramji & Co.	Do. . .	M. L. .	13	21st February 1922.	5 years.
Do. .	(364) Messrs. Ramprasad Laxmi Narayan.	Do. . .	P. L. .	16	9th December 1922.	1 year.
Do. .	(365) Do. .	Do. . .	P. L. .	5	Do. .	Do.
Do. .	(366) Messrs. Lalbehari Narayandas and Ramcharan Shankerlal.	Do. . .	P. L. .	12	13th October 1922.	Do.
Do. .	(367) The Indian Manganese Co., Ltd.	Manganese . .	M. L. .	106	5th December 1922.	10 years.
Do. .	(368) Messrs. Bhamanshah Fouzdar Bros.	Mica . . .	P. L. .	35	13th October 1922.	1 year.
Do. .	(369) Do. .	Do. . . .	P. L. .	37	Do. .	Do.
Betul .	(370) Seth Laxmichand .	Lead . . .	M. L. .	1271·63	24th January 1922.	30 years.
Do. .	(371) Sheikh Shahabuddin.	Coal . . .	M. L. .	123·78	13th December 1921.	15 years.
Do. .	(372) Do. .	Do. . . .	M. L. .	67·69	12th January 1922.	10 years.
Do. .	(373) Seth Jamnadass Potdar.	Do. . . .	M. L. .	111·39	14th December 1921.	30 years.
Do. .	(374) Do. .	Do. . . .	M. L. .	630·16	23rd December 1921.	Do.
Do. .	(375) Seth Raghunath .	Graphite . .	P. L. .	156·44	3rd January 1922.	1 year.
Do. .	(376) Shyamlal Patel .	Mica . . .	P. L. .	253·54	17th February 1922.	Do.
Do. .	(377) Seth Raghunath .	Iron and Ferric oxide.	P. L. .	188·26	22nd February 1922.	Do.
Do. .	(378) Mr. Kedarnath Bhargava.	Coal . . .	P. L. .	346·03	21st March 1922.	Do.
Do. .	(379) Do. .	Do. . . .	P. L. .	59·24	Do. .	Do.
Do. .	(380) The Coal Bunkering & Shipping Co., Ltd., Calcutta.	Do. . . .	M. L. .	1,150	14th June 1922.	30 years.
Do. .	(381) Bansidhar Ramniwas.	Do. . . .	P. L. .	404·31	8th May 1922	1 year.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Betul	(382) Betul Mining Syndicate.	Coal	P. L.	454·40	21st June 1922.	1 year.
Do.	(383) Mr. C. Stanley Harris.	Do.	P. L.	550	18th July 1922.	Do.
Do.	(384) Mr. W. M. Moylan	Do.	P. L.	301	1st August 1922.	Do.
Do.	(385) Do.	Do.	P. L.	833	3rd July 1922	Do.
Do.	(386) Seth Bansidhar Ramniwas.	Do.	M. L.	197	9th August 1922.	30 years.
Do.	(387) Do.	Do.	M. L.	622	Do.	10 years.
Do.	(388) Mr. W. M. Moylan	Do.	P. L.	226	25th September 1922.	1 year.
Do.	(389) Seth Laxmichand	Do.	P. L.	546	5th October 1922.	Do.
Do.	(390) Haji Saiyad Zahir-uddin.	Do.	P. L.	311	6th October 1922.	Do.
Do.	(391) Betul Mining Syndicate.	Do.	P. L.	332	24th October 1922.	Do.
Do.	(392) Rai Sahib Jugal Kishore.	Do.	P. L.	251	16th October 1922.	Do.
Do.	(393) Do.	Do.	P. L.	178	Do.	Do.
Do.	(394) Mr. Balaji Vinayak Buti.	Do.	P. L.	508	4th October 1922.	Do.
Do.	(395) Patel Kesh Ram	Do.	P. L.	260	7th October 1922.	Do.
Do.	(396) Mr. Danji Deosi	Do.	P. L.	524	11th November 1922.	Do.
Do.	(397) Do.	Do.	P. L.	196	Do.	Do.
Bhandara	(398) Mr. Ganpat Rao Laxman.	Manganese	P. L.	4	23rd March 1922.	Do.
Do.	(399) Mr. M. A. Pasha, Minor, Guardian Munshi S. Alimuddin.	Do.	P. L.	47	16th May 1922.	Do.
Do.	(400) Mr. Shriram Seth	Do.	M. L.	20	10th July 1922.	30 years.
Do.	(401) Do.	Do.	M. L.	90	15th September 1922.	Do.
Bilaspur	(402) Messrs. Chari & Co.	Coal	P. L. (renewal.)	1,630	18th January 1922.	1 year.
Do.	(403) Shamji Narainji of Ramtek.	Mica	P. L.	79·29	6th May 1922	Do.
Do.	(404) Captain W. J. Considine and Messrs. Dunlop Bros. & Co.	Coal	M. L.	274	20th July 1922.	30 years.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chanda .	(405) Messrs. Jagjivan Vallabhdas Padamsey & Co., Bombay.	Coal . . .	P. L. .	93	18th February 1922.	1 year.
Do. .	(406) Do. .	Do. . . .	P. L. .	46	Do. .	Do.
Do. .	(407) Messrs. J. K. Karaka & Co., Bombay.	Do. . . .	P. L. .	465	3rd January 1922.	Do.
Do. .	(408) Rai Sahib D. Laxmi Narayan of Kamptee.	Do. . . .	P. L. .	1,194	13th March 1922.	Do.
Do. .	(409) Do. .	Do. . . .	P. L. .	428	Do. .	Do.
Do. .	(410) Messrs. Maharaj Kishan & Co., Chhindwara	Do. . . .	P. L. .	862	26th January 1922.	Do.
Do. .	(411) Messrs. J F. Karaka & Co.	Do. . . .	M. L. .	920	31st August 1922.	30 years.
Do. .	(412) Do .	Iron-ore . .	M. L. .	21	18th July 1922.	Do.
Do. .	(413) Do. .	Do. . .	M. L. .	25	Do. .	Do.
Do. .	(414) Do. .	Do. . .	M. L. .	79	Do. .	Do.
Do. .	(415) Balaghat Manganese Mining Co.	Coal . . .	P. L.	1,914	31st July 1922.	1 year.
Do. .	(416) Mr. P. C. Dutta .	Do. . . .	P. L .	587	2nd August 1922.	Do.
Do. .	(417) Rao Sahib D. Laxmi Narayan.	Do. . . .	P. L. .	1,603	1st August 1922.	Do.
Do. .	(418) Diwan Bahadur Seth Ballabdas.	Do. . . .	P. L. .	267	16th June 1922.	Do.
Do. .	(419) Do. .	Do. . . .	P. L. .	350	18th August 1922.	Do.
Do. .	(420) Messrs. Hassambhoy & Sons.	Bauxite . .	P. L. .	251	1st December 1922.	Do.
Do. .	(421) Rai Sahib Minamal and Mr. Nandlal.	Coal . . .	M. L. .	346	20th December 1922.	30 years.
Chhindwara.	(422) Seth Lakhmichand, Betul.	Manganese . .	M. L. .	149·20	27th January 1922.	Do.
Do. .	(423) Do. .	Do. . .	M. L. .	85·78	25th January 1922.	Do.
Do. .	(424) Do. .	Do. . .	M. L. .	60·21	27th January 1922.	Do.
Do. .	(425) Messrs. A. H. Wasudeo Rao Bros.	Coal . . .	P. L. .	135·25	16th February 1922.	1 year.
Do. .	(426) Captain L. Newton	Do.. . .	P. L. .	253	9th March 1922.	Do.
Do. .	(427) Do. .	Do. . .	P. L. .	385·06	Do. .	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chhindwara.	(428) Mr. W. N. Moylan	Coal . . .	P. L. .	408·43	14th January 1922.	1 year.
Do. .	(429) Messrs. H. Verma and Munshi Kanhaiyalal.	Do. . . .	P. L. .	392·30	15th March 1922.	Do.
Do. .	(430) Captain Leonard Newton.	Do. . . .	P. L. .	574·09	9th March 1922.	Do.
Do. .	(431) K. S. M. Hasanji & Sons.	Do. . . .	P. L. .	646·08	10th January 1922.	Do.
Do. .	(432) Messrs. M. L. Bharadwaj & Co.	Do. . . .	P. L. .	192	23rd March 1922.	Do.
Do. .	(433) Lala Beharilal of Rewari.	Do. . . .	P. L. .	190·72	6th January 1922.	Do.
Do. .	(434) R. S. A. P. Bhargava, Bar.-at-Law.	Do. . . .	P. L. .	160·29	15th March 1922.	Do.
Do. .	(435) Do. .	Do. . . .	P. L. .	117·93	Do.	Do.
Do. .	(436) Pandit Kirpa Shankar.	Do. . . .	P. L. .	225·09	3rd January 1922.	Do.
Do. .	(437) Do. .	Do. . . .	P. L. .	106·42	18th January 1922.	Do.
Do. .	(438) Messrs. M. Bharadwaj and others.	Do. . . .	P. L. .	89·18	Do. .	Do.
Do. .	(439) Messrs. Bharadwaj & Co.	Do. . . .	P. L. .	73·46	23rd March 1922.	Do.
Do. .	(440) Seth Sheolal, M. L. C.	Do. . . .	P. L. .	259·71	21st March 1922.	Do.
Do. .	(441) Do. .	Do. . . .	P. L. .	111·82	Do. .	Do.
Do. .	(442) K. B. Mohammad Ali Abdul Kadir.	Do. . . .	P. L. .	388·65	21st February 1922.	Do.
Do. .	(443) Do. .	Do. . . .	P. L. .	195·48	4th February 1922.	Do.
Do. .	(444) Do. .	Do. . . .	P. L. .	384·59	21st February 1922.	Do.
Do. .	(445) Do. .	Do. . . .	P. L. .	437·85	Do. .	Do.
Do. .	(446) M. D'Costa, & Goaredatt Ganeshlal.	Manganese . .	P. L. .	349·31	6th January 1922.	Do.
Do. .	(447) Lala Beharilal .	Coal . . .	P. L. .	166·30	6th February 1922.	Do.
Do. .	(448) K. B. Mohammad Ali Abdul Kadir.	Do. . . .	P. L. .	255·66	21st February 1922.	Do.
Do. .	(449) Do. .	Do. . . .	P. L. .	250·12	Do. .	Do.
Do. .	(450) Kedarnath Bhargava.	Do. . . .	P. L. .	87·99	21st January 1922.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chhindwara.	(451) Seth Sheolal, M. L. C.	Coal . . .	P. L. .	398·68	21st March 1922.	1 year.
Do. .	(452) K. S. Minamal Nandlal.	Do. . . .	P. L. .	78·46	13th February 1922.	Do.
Do. .	(453) Pandit Thakur Prasad.	Do. . . .	P. L. .	153·88	18th January 1922.	Do.
Do. .	(454) Do. .	Do. . . .	P. L. .	190·47	Do. .	Do.
Do. .	(455) Pandit Kedarnath Bhargava.	Do. . . .	P. L. .	108·15	21st January 1922.	Do.
Do. .	(456) Seth Sheolal, M. L. C.	Do. . . .	P. L. .	83·91	21st March 1922.	Do.
Do. .	(457) S. Haji Zahiruddin	Do. . . .	P. L. .	314·96	Do. .	Do.
Do. .	(458) Lala Jagannath Prasad Bros. & Co.	Do. . . .	P. L. .	442·03	30th March 1922.	Do.
Do. .	(459) Do. .	Do. . . .	P. L. .	110·61	Do. .	Do.
Do. .	(460) S. Haji Zahiruddin.	Do. . . .	P. L. .	401·44	28th March 1922.	Do.
Do. .	(461) Rai Sahib Seth Minamal Nandlal.	Manganese . .	P. L. .	71·08	20th February 1922.	Do.
Do. .	(462) Messrs. Bharadwaj, Sheonarayan & Co.	Coal . . .	P. L. .	48	23rd March 1922.	Do.
Do. .	(463) Haji Zahiruddin .	Manganese . .	P. L. .	225·22	28th March 1922.	Do.
Do. .	(464) Lalla Baijnath Kalar.	Coal . . .	P. L. .	561·80	23rd February 1922.	Do.
Do. .	(465) Do. .	Do. . . .	P. L. .	437·21	Do. .	Do.
Do. .	(466) Mr. W. M. Moylan	Do. . . .	P. L. .	621·01	31st May 1922	Do.
Do. .	(467) Messrs. Bharadwaj and others.	Do. . . .	P. L. .	68·16	27th May 1922.	Do.
Do. .	(468) Kedarnath Bhargava.	Do. . . .	P. L. .	237·45	4th May 1922	Do.
Do. .	(469) Do. .	Do. . . .	P. L. .	176	5th June 1922.	Do.
Do. .	(470) Messrs. Bharadwaj Sheonarayan & Co.	Do. . . .	P. L. .	284	27th May 1922.	Do.
Do. .	(471) Messrs. Maharaj Kishen & Co.	Do. . . .	P. L. .	153·37	10th April 1922.	Do.
Do. .	(472) Do. .	Do. . . .	P. L. .	126·60	Do. .	Do.
Do. .	(473) Mr. Bakaram Singh	Manganese . .	P. L. .	9·54	13th May 1922	Do.
Do. .	(474) Seth Hazarilal .	Coal . . .	P. L. .	247·81	5th April 1922.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chhindwara.	(475) Kedarnath Bhargava.	Coal . . .	P. L. .	301·55	5th June 1922.	1 year.
Do. .	(476) Budhulal . .	Do. . . .	P. L. .	443·26	5th April 1922.	Do.
Do. .	(477) Messrs. Dhanulall and others.	Do. . . .	P. L. .	116·72	27th April 1922.	Do.
Do. .	(478) Seth Hazarimal .	Do. . . .	P. L. .	100·09	17th June 1922.	Do.
Do. .	(479) Rai Sahib Mathura Prasad, Motilal & Co.	Do. . . .	P. L. .	103·02	5th April 1922.	Do.
Do. .	(480) Seth Hazarimal .	Do. . . .	P. L. .	146·79	4th May 1922	Do.
Do. .	(481) Chaitram Sao and Tikaram Sao.	Do. . . .	P. L. .	163·19	5th June 1922.	Do.
Do. .	(482) Do. .	Do. . . .	P. L. .	82·34	17th June 1922.	Do.
Do. .	(483) Do. .	Do. . . .	P. L. .	215	5th June 1922.	Do.
Do. .	(484) Do. .	Do. . . .	P. L. .	40	17th June 1922.	Do.
Do. .	(485) Do. .	Do. . . .	P. L. .	610·68	Do. .	Do.
Do. .	(486) Messrs. H. Varma and Munshi Kanhaiyalal.	Do. . . .	M. L. .	237·72	27th April 1922.	30 years.
Do. .	(487) Rai Sahib Mathura Prasad Motilal & Co.	Do. . . .	M. L. .	29·99	10th May 1922.	Do.
Do. .	(488) Seth Laxmichand, Betul.	Do. . . .	M. L .	181·72	4th May 1922	Do.
Do. .	(489) Rai Sahib A. P. Bhargava.	Do. . . .	M. L. .	238·87	12th April 1922.	Do.
Do. .	(490) Seth Laxmichand, Betul.	Do. . . .	M. L. .	72·72	27th May 1922.	Do.
Do. .	(491) Do. .	Do. . . .	M. L. .	107·96	Do. .	Do.
Do. .	(492) Seth Laxmichand, Seoni.	Do. . . .	M. L. .	444	8th May 1922	Do.
Do. .	(493) Rai Sahib A. P. Bhargava.	Do. . . .	P. L. .	322	17th July 1922.	1 year.
Do. .	(494) Seth Naraindas .	Do. . . .	P. L. .	300	8th September 1922.	Do.
Do. .	(495) Seth Giridharilal .	Manganese . .	P. L. .	140	12th August 1922.	Do.
Do. .	(496) Do. .	Mica . . .	P. L. .	200	Do. .	Do.
Do. .	(497) Rai Sahib A. P. Bhargava.	Coal . . .	P. L. .	494	19th August 1922.	Do.
Do. .	(498) Indian Manganese Co.	Manganese . .	P. L. .	17	14th August 1922.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chhindwara.	(499) Messrs. Bharadwaj, Sheonarayan & Co.	Coal . . .	P. L. .	179	22nd September 1922.	1 year.
Do. .	(500) Mr. Kedarnath Bhargava.	Do. . . .	P. L. .	141	30th August 1922.	Do.
Do. .	(501) Lala Baijnath Kalar.	Do. . . .	P. L. .	223	9th August 1922.	Do.
Do. .	(502) Seth Hazarilal .	Do. . . .	P. L. .	304	16th September 1922.	Do.
Do. .	(503) S. H. Zahiruddin	Do. . . .	P. L. .	213	26th September 1922.	Do.
Do. .	(504) Do. .	Do. . . .	P. L. .	533	18th July 1922.	Do.
Do. .	(505) Messrs. Dharmalal and others.	Do. . . .	P. L. .	95	21st July 1922.	Do.
Do. .	(506) Rai Sahib Mannimal Nandlal.	Do. . .	P. L. .	151	6th July 1922	Do.
Do. .	(507) Seth Hazarilal .	Do. . . .	P. L. .	139	17th July 1922.	Do.
Do. .	(508) Messrs. Chaitram Tikaram Sao.	Do. . . .	P. L .	35	29th August 1922.	Do.
Do. .	(509) Rai Sahib H. Varma and Munshi Kanhaiyalal.	Do. . . .	M. L. .	231	4th July 1922	30 years.
Do .	(510) Do. .	Do. . . .	M. L. .	78 27	25th July 1922.	Do.
Do. .	(511) Rai Sahib Mathura Prasad Motilal & Co.	Do. . . .	M. L. .	1	3rd July 1922	Do.
Do. .	(512) Do. .	Do. . . .	M. L. .	131	6th September 1922.	Do.
Do. .	(513) Seth Laxmichand, Betul.	Do. . . .	M. L .	250	25th July 1922.	Do.
Do. .	(514) Do. .	Do. . . .	M. L. .	177	8th September 1922.	Do.
Do. .	(515) Messrs. A. H. Wasudeo Rao & Bros.	Do. . . .	M. L. .	48	8th August 1922.	Do.
Do. .	(516) Rai Sahib A. P. Bhargava.	Do. . . .	M. L. .	44	13th September 1922.	Do.
Do. .	(517) Rai Sahib Seth Gowardhan Dass.	Do. . . .	P. L. .	154	17th October 1922.	1 year.
Do. .	(518) Indian Manganese Co.	Manganese . .	P. L. .	220	24th November 1922.	Do.
Do. .	(519) Pandit Thakur Prasad Avasthi.	Coal . . .	P. L. .	116	8th December 1922.	Do.
Do. .	(520) Do. .	Do. . . .	P. L. .	47	Do. .	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chhindwara.	(521) Pandit Kedarnath Bhargava.	Coal . . .	P. L. .	73	12th December 1922.	1 year.
Do. .	(522) Do. .	Do. . . .	P. L. .	216	31st October 1922.	Do.
Do. .	(523) Mr. A. V. Wazalwar.	Do. . . .	P. L. .	100	22nd December 1922.	Do.
Do. .	(524) Messrs. Bharadwaj Sheo Narayan & Co.	Do. . .	P. L. .	236	28th October 1922.	Do.
Do. .	(525) Pandit Thakur Prosad Avasthi.	Do. . . .	P. L. .	201	7th October 1922.	Do.
Do. .	(526) Indian Manganese Co.	Manganese . .	P. L. .	188	24th November 1922.	Do.
Do. .	(527) Lala Baijnath Kalar.	Coal . . .	P. L. .	48	22nd December 1922.	Do.
Do. .	(528) Mr. Bansidhar Ramnivas.	Do. . . .	P. L. .	724	26th October 1922.	Do.
Do. .	(529) Dewan Bahadur Ballabhdass.	Do. . . .	P. L. .	191	11th December 1922.	Do.
Do. .	(530) Seth Girdharilal .	Do. . . .	P. L. .	250	11th October 1922.	Do.
Do. .	(531) Mr. A. V. Wazalwar.	Do. . . .	P. L. .	545	1st November 1922.	Do.
Do. .	(532) Messrs. Bharadwaj Sheo Narayan & Co.	Do. . . .	P. L. .	195	22nd December 1922.	Do.
Do. .	(533) Messrs. Dhannoolal and others.	Do. . . .	P. L. .	102	27th October 1922.	Do.
Do. .	(534) Mr. Noor Mohammad Mitha.	Do. . . .	P. L. .	143	16th October 1922.	Do.
Do. .	(535) Mr. Chedilal .	Do. . . .	P. L. .	464	16th November 1922.	Do.
Do. .	(536) Seth Hazarimal Hazaz.	Do. . . .	P. L. .	169	12th October 1922.	Do.
Do. .	(537) Do. .	Do. . . .	P. L. .	90	Do. .	Do.
Do. .	(538) Syed Minhajuddin Ahmad.	Manganese . .	P. L. .	76	28th November 1922.	Do.
Do. .	(539) Messrs. Dhannoolal and others.	Coal . . .	P. L. .	189	Do. .	Do.
Do. .	(540) Do. .	Do. . . .	P. L. .	68	27th October 1922.	Do.
Do. .	(541) Mr. Chedilal Chaodhri.	Do. . . .	P. L. .	136	16th November 1922.	Do.
Do. .	(542) Messrs. Bharadwaj Sheo Narayan & Co.	Do. . . .	P. L. . (Supplementary).	17	26th October 1922.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral	Nature of grant.	Area in acres	Date of commencement.	Term.
Chhindwara.	(543) Messrs. R. G. Mote and L. R. Mote of Amraoti.	Coal . . .	P. L. .	84	10th October 1922.	1 year.
Do. .	(544) Messrs. Chait Ram Tikaram Sao.	Do. . . .	P. L. .	177	2nd October 1922.	Do.
Do. .	(545) Do. .	Do. . .	P. L. .	105	27th October 1922.	Do.
Do. .	(546) Rai Sahib Gowardhan Dass.	Do. . . .	P. L. .	196	Do. .	Do.
Do. .	(547) Seth Girdharilal .	Do. . . .	P. L. .	65	11th October 1922.	Do.
Do. .	(548) Mr. Noor Mohammad Mihta.	Do. . . .	P. L. .	612	16th October 1922.	Do.
Do. .	(549) Do. .	Do. . . .	P. L. .	385	2nd December 1922.	Do.
Do. .	(550) Messrs. Dhannoolal and others.	Do. . . .	P. L. .	61	28th November 1922.	Do.
Do. .	(551) Messrs. R. G. Mote and L. R. Mote.	Do. . . .	P. L. .	286	30th November 1922.	Do.
Do. .	(552) Seth Laxmichand of Betul.	Do. . . .	M. L. .	95	20th November 1922.	30 years.
Do. .	(553) Do. .	Do. . . .	M. L. .	103	Do. .	Do.
Do. .	(554) Rai Sahib Mathura Prasad, Motilal & Co.	Do. . . .	M. L. .	1	9th September 1922. 2nd October 1922.	Do.
Do. .	(555) Captain Leonard Newton.	Do. . . .	M. L. .	114	16th November 1922.	Do.
Do. .	(556) Rai Sahib Seth Minamel and Mr. Nandlal.	Do. . . .	M. L. .	78	16th September 1922. 5th October 1922.	Do.
Hoshangabad	(557) Rai Sahib Jugalkishore of Itarsi.	Coal . . .	P. L. .	105·4	28th June 1922.	1 year.
Jubbulpore.	(558) Mr. Venkat Ramanna.	Bauxite . .	M. L. .	37·87	11th February 1922.	30 years.
Do. .	(559) Indian Industrial and General Syndicate, Ltd., London.	Copper, gold, silver, barytes, lead and manganese.	M. L. .	123	2nd August 1922.	Do.
Do. .	(560) Tata Iron and Steel Co., Ltd.	Bauxite . .	P. L. .	12	17th July 1922.	1 year.
Do. .	(561) Do. .	Do. . .	P. L. .	62	9th September 1922.	Do.
Do. .	(562) Do. .	Do. . .	P. L. .	544	Do. .	Do.
Do. .	(563) Diwan Bahadur Seth Ballabh Dass.	Manganese, coal and bauxite.	P. L. .	76	21st July 1922.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jubbulpore .	(564) Olpherts Paints & Products, Ltd.	Bauxite . .	P. L. .	252	8th September 1922.	1 year.
Do. .	(565) Do. .	Do. . .	P. L. .	500	Do. .	Do.
Do. .	(566) Do. .	Do. . .	P. L. .	27	Do. .	Do.
Do. .	(567) Tata Electric Chemicals Ltd.	Do. . .	P. L. .	1,800	15th December 1922.	Do.
Do. .	(568) Do. .	Do. . .	P. L. .	23	Do. .	Do.
Do. .	(569) Do. .	Do. . .	P. L. .	586	7th October 1922.	Do.
Nagpur .	(570) Rai Sahib Ramkrishna Puri Gosai.	Manganese . .	P. L. .	63	27th January 1922.	Do.
Do. .	(571) Do. .	Do. . .	P. L. .	68	Do. .	Do.
Do. .	(572) Do. .	Do. . .	M. L. .	56	11th January 1922.	30 years.
Do. .	(573) Do. .	Do. . .	M. L. .	147	Do. .	15 years.
Do. .	(574) Mr. B. N. Soparkar.	Do. . .	P. L. .	313	27th February 1922.	1 year.
Do. .	(575) Do. .	Do. . .	P. L. .	32	27th January 1922.	Do.
Do. .	(576) Do. .	Do. . .	P. L. .	31	Do. .	Do.
Do. .	(577) Nagpur Manganese Mining Syndicate.	Do. . .	P. L. .	73	Do. .	Do.
Do. .	(578) K. S. Mahomed Ali Hasanji.	Do. . .	P. L. .	58·1	9th March 1922.	Do.
Do. .	(579) The Central India Mining Co.	Do. . .	P. L.	26	10th January 1922.	Do.
Do. .	(580) The Indian Manganese Mining Co.	Do. . .	P. L.	127	Do. .	Do.
Do. .	(581) Seth Mahanandram Sheonarayan.	Do. . .	M. L. .	68	4th January 1922.	10 years.
Do. .	(582) The Central Provinces Prospecting Syndicate.	Do. . .	M. L. .	25	8th February 1922.	9 years 5 months and 28 days.
Do. .	(583) Seth Gowardhan Dass.	Do. . .	M. L. .	27	Do. .	30 years.
Do. .	(584) Mr. Tayaballi Kamruddin.	Do. . .	P. L. .	33	15th June 1922.	1 year.
Do. .	(585) R. S. Ramkrishna Puri Gosai.	Do. . .	P. L. .	112·79	22nd June 1922.	Do.
Do. .	(586) Seth Banshidhar Ramniwas.	Do. . .	P. L. .	162	20th June 1922.	Do.
Do. :	(587) Mr. M. V. Kaore.	Do. . .	P. L. .	65	21st April 1922.	Do.
Do. .	(588) Do. .	Do. . .	P. L. .	222	Do. .	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(589) The Nagpur Manganese Mining Syndicate.	Manganese . .	P. L. .	131	9th June 1922.	1 year.
Do. .	(590) Do. .	Do. . .	M. L. .	12	29th April 1922.	20 years.
Do. .	(591) Do. .	Do. . .	M. L. . (Supplementary).	1	20th May 1922	14 years and 11 days, up to 31st May 1936.
Do. .	(592) Messrs. B. P. Byramji & Co.	Coal . . .	P. L. .	1,082	21st April 1922.	1 year.
Do. .	(593) The Indian Manganese Co.	Manganese . .	P. L. .	·59	9th May 1922	Do.
Do. .	(594) Do. .	Do. . .	P. L. .	61	8th June 1922.	Do.
Do. .	(595) The Nagpur Manganese Mining Syndicate.	Do. . .	P. L. .	23	1st August 1922.	Do.
Do. .	(596) Mr. Laxman Damodar Lele.	Do. . .	P. L. .	22	Do. .	Do.
Do. .	(597) Seth Laxmi Narayan.	Do. . .	P. L. .	153	Do. .	Do.
Do. .	(598) Seth Bansidhar Ramniwas.	Do. . .	P. L. .	1	6th September 1922.	Do.
Do. .	(599) Do. .	Do. . .	P. L. .	7	Do. .	Do.
Do. .	(600) Do. .	Do. . .	P. L. .	7	Do. .	Do.
Do. .	(601) The C. P. Prospecting Syndicate.	Do. . .	M. L. .	15	22nd September 1922.	8 years 10 months and 9 days.
Do. .	(602) The Central India Mining Co.	Do. . .	P. L. .	201	1st November 1922.	1 year.
Do. .	(603) Do. .	Do. . .	P. L. .	17	Do. .	Do.
Do. .	(604) Mr. Shamji Narayanji.	Do. . .	P. L. .	5	22nd November 1922.	Do.
Do. .	(605) The Indian Manganese Co.	Do. . .	P. L. .	52	Do. .	Do.
Do. .	(606) Seth Shrikisan Hazarimal.	Do. . .	P. L. .	115	14th November 1922.	Do.
Do. .	(607) Mr. Ganpat Rao Laxman.	Do. . .	P. L. .	81	4th December 1922.	Do.
Do. .	(608) Do. .	Do. . .	P. L. .	30	Do. .	Do.
Do. .	(609) Rai Saheb Seth Narsingdas.	Do. . .	P. L. .	140	1st November 1922.	Do.
Do. .	(610) Messrs. Ramprasad Laxmi Narayan.	Do. . .	P. L. .	88	15th December 1922.	Do.

P. L. = *Prospecting Licence.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*concld.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Narsinghpur	(611) The Narsinghpur Pottery and Industrial Co.	Coal, felspar and manganese.	P. L. .	1,678	31st May 1922.	1 year.
Do. .	(612) Mr. C. Stanley Harris.	Copper . .	P. L. .	222	26th July 1922.	Do.
Saugor .	(613) Lala Prag Narain, Pleader, Agra.	Iron, pyrites, sulphate of iron and sulphur.	P. L. . (renewal.)	75	5th September 1919.	Do.
Do. .	(614) Do. .	Iron, pyrites, sulphate of iron, sulphur and copper.	P. L. .	1,554	20th May 1922.	Do.
Yeotmal .	(615) Messrs. Metcalfe & Co., Calcutta.	Coal . . .	M. L. .	563	19th August 1922.	30 years.
Do. .	(616) Do. .	Do. . . .	M. L. .	1,290	Do. .	Do.
Do. .	(617) Messrs. J. F. Karaka & Co., Bombay.	Do. . . .	P. L. .	461	23rd October 1922.	1 year.
Do. .	(618) Do. .	Do. . . .	M. L. .	1,376	23rd November 1922.	30 years.

MADRAS.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Agency Division.	(619) Messrs. Best & Co.	Coal . . .	P. L. .	5,280	11th April 1922.	1 year.
Do. .	(620) Do. . .	Do. . .	P. L. .	51,200	Do.	Do.
Anantapur .	(621) Anantapur Gold Fields, Ltd.	Gold . . .	P. L. .	3,604·81	23rd January 1922.	Do.
Do. .	(622) The North Anantapur Gold Mines, Ltd.	Do. . . .	P. L. .	320	3rd February 1922.	Do.
Do. .	(623) Do. . .	Do. . .	P. L. .	1,769·52	22nd July 1922.	Do.
Do. .	(624) Magam B. Venkatesam.	Barytes . .	P. L. .	1,203·49	10th December 1922.	Do.
Guntur .	(625) Messrs. Gillanders Arbuthnot Co., Managing Agents of the General Prospecting Co., Ltd., Calcutta.	Diamond . .	P. L. .	4,270	12th April 1922.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

MADRAS—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Karnool .	(626) M. R. Ry. B. P. Sesha Reddi of Betamcherla.	Barytes . .	P. L. .	4·04	9th August 1922.	1 year.
Do. .	(627) Do. .	Do. . .	P. L. .	4·07	Do. .	Do.
Do. .	(628) Do. .	Do. . .	P. L. .	10·05	Do. .	Do.
Do. .	(629) Do. .	Do. . .	P. L. .	6·67	17th July 1922.	Do.
Do. .	(630) Do. .	Do. . .	P. L. .	1·20	9th August 1922.	Do.
Nellore .	(631) M. R. Ry. R. K. Srinivasan.	Mica . . .	M. L. .	39·22	16th October 1921.	30 years.
Do. .	(632) Mr. A. H. Gaston .	Do. . .	P. L. .	8·93	23rd March 1922.	1 year.
Do. .	(633) M. R. Ry. Dodla Venkata Rami Reddi.	Do. . .	P. L. .	67·14	25th February 1922.	Do.
Do. .	(634) M. R. Ry. Vazaraju Venkatasubbayya Garu.	Do. . .	P. L. .	8·32	11th May 1922.	Do.
Do. .	(635) Messrs. The Madras Mica Co., Ltd.	Do. . .	P. L. .	4·72	20th May 1922.	Do.
Do. .	(636) M. R. Ry. Kondamur Venkatasubbayya Nayudu.	Do. . .	M. L. .	40·50	26th March 1922.	30 years.
Do. .	(637) Venkata Subbayya Nayudu.	Do. . .	M. L. .	6·52	Not stated. .	Not stated.
Do. .	(638) S. Lakshmi Narasimham.	Do. . .	M. L. .	37·21	30th October 1922.	30 years.
Do. .	(639) R. Sundara Rama Reddi Garu.	Do. . .	M. L. .	36·59	3rd April 1922.	Do.
Do. .	(640) M. Varda Reddi .	Do. . .	M. L. .	21·30	3rd December 1922.	Do.
Do. .	(641) S. Venkataramanayya Salivendra.	Do. . .	M. L. .	75·90	15th November 1922.	Do.
Do. .	(642) R. Sundara Rama Reddi Garu.	Do. . .	M. L. .	1·79	30th October 1922.	Do.
Do. .	(643) P. Viraraghavalu Chettiyar.	Do. . .	M. L. .	2·36	14th December 1922.	Do.
Do. .	(644) Do. . .	Do. . .	M. L. .	48·28	Do. .	Do.
Do. .	(645) N. Raghavalu Nayakar.	Do. . .	M. L. .	37·40	3rd November 1922.	Do.
Do. .	(646) R. K. Subbaraghava Ayyar.	Do. . .	M. L. .	108·00	14th December 1922.	Do.
Do. .	(647) P. Viraraghavalu Chettiyar.	Do. . .	M. L. .	34·71	Do. .	Do.
Do. .	(648) Mehorji Cowasji .	Do. . .	M. L. .	7·81	30th October 1922.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

MADRAS—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nellore .	(649) Yellasiri Subba Reddi.	Mica . . .	M. L. .	21·74	15th November 1922.	30 years.
Do. .	(650) Aukula Penchalu Chetti.	Do. . .	M. L. .	18·81	Do. .	Do.
Do. .	(651) R. Sundararama Reddi.	Do. . .	M. L. .	3·7	30th October 1922.	Do.
Do. .	(652) Yellasiri Subba Reddi.	Do. . .	M. L. .	22·95	15th November 1922.	Do.
Do. .	(653) S. V. Subba Reddi	Do. . .	P. L. .	16·64	6th July 1922	1 year.
Do. .	(654) Isanaka Rama Subba Reddi.	Do. . .	M. L. .	3·75	3rd November 1922.	30 years.
Do. .	(655) K. C. Narasinhachariyar.	Do. . .	P. L. .	188·16	6th October ber 1922.	1 year.
North Arcot	(656) M R. Ry. R. K. Subbaraghava Ayyar.	Nitrate of copper and allied minerals.	P. L. .	840	28th February 1922.	Do.
Salem .	(657) Mr. Gaudart of Pondicherry.	Iron-ore . .	M. L. .	4,309	..	30 years.
South Kanara.	(658) Devamma Naraina Shet.	Corundum . .	P. L. .	377·65	13th December 1922.	1 year.
Do. .	(659) Nagar Srinivasa Rao.	Do. . .	P. L. .	73·77	Do. .	Do.
Tinnevelly .	(660) M. R. Ry. K. S. Paramanayagam Pillai.	Do. . .	P. L. .	10·03	3rd October 1922.	Up to midnight of 31st December 1922.

NORTH-WEST FRONTIER PROVINCE.

Bannu .	(661) The Whitehall Corporation, Ltd., Lahore.	Crude petroleum and its associated hydro-carbons.	P. L . .	1,120	25th September 1922.	1 year.

PUNJAB.

Jhelum .	(662) Whitehall Petroleum Corporation, Ltd.	Mineral oil . .	P. L. .	10,240	6th September 1922.	1 year.
Do. .	(663) Do. .	Do. . .	P. L. .	1,033·60	Do. .	Do.
Do. .	(664) Do. .	Do. . .	P. L. .	8,960	Do. .	Do.
Do. .	(665) K. B. Raja Painda Khan.	Coal . . .	P. L. .	26	3rd October 1922.	Do.
Do. .	(666) Do. .	Do. . . .	P. L. .	22	Do. .	Do.
Do. .	(667) Do. .	Do. . . .	P. L. .	84	Do. .	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

PUNJAB—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jhelum .	(668) L. Atma Ram Kapur.	Coal	P. L. .	586·76	3rd October 1922.	1 year.
Do. .	(669) Bhagat Beli Ram & Co.	Do.	P. L. .	48	21st November 1922.	Do.
Do. .	(670) Do. .	Do.	P. L. .	94	22nd December 1922.	Do.
Do. .	(671) Pandit Gian Chand.	Do.	P. L. .	243	Do. .	Do.
Do. .	(672) L. Isher Das Kapur.	Do.	P. L. .	7	Do. .	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

SUMMARY.

PROVINCE.	Exploring License.	Prospecting License.	Mining Lease.	Total of each Province.
Assam	..	9	1	10
Baluchistan	..	1	8	9
Bengal	..	3	..	3
Bihar and Orissa	..	4	12	16
Burma	..	249	9	258
Central Provinces	..	262	60	322
Madras	..	22	20	42
North-West Frontier Province . . .	..	1	..	1
Punjab	..	11	..	11
Total of each kind and grand total for 1922.	..	562	110	672
TOTAL FOR 1921 .	4	563	84	651

CLASSIFICATION OF LICENSES AND LEASES.

TABLE 39.—*Prospecting Licenses and Mining Leases granted in Assam during 1922.*

DISTRICT.	1922.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Cachar	4	12,643·86	Mineral oil.
Lakhimpur	1	5,120	Oil.
Sibsagar	3	11,328	Petroleum.
Sylhet	1	3,136	Mineral oil.
TOTAL	9	..	
Mining Lease.			
Lakhimpur	1	4,896	Coal, iron, fire-clay and shale.

TABLE 40.—*Prospecting Licenses and Mining Leases granted in Baluchistan during 1922.*

DISTRICT.	1922.		
	No.	Area in acres.	Mineral.
Prospecting License.			
Kalat	1	3,200	Oil.
Mining Leases.			
Kalat	2	298	Coal.
Sibi	1	160	Do.
Zhob	5	50	Chromite.
TOTAL	8	..	

TABLE 41.—*Prospecting Licenses granted in Bengal during 1922.*

District.	1922. No.	Area in acres.	Mineral.
Chittagong	1	3,082	Mineral oil.
Chittagong Hill Tracts	2	36,480	Do.
TOTAL	3	..	

TABLE 42.—*Prospecting Licenses and Mining Leases granted in Bihar and Orissa during 1922.*

District.	1922. No.	Area in acres.	Mineral.
Prospecting Licenses.			
Hazaribagh	2	80	Mica.
Sambalpur	1	280·57	Do.
Do.	1	1,849·21	Coal.
TOTAL	4	..	
Mining Leases.			
Hazaribagh	3	599·75	Mica.
Palamau	1	1,240	Coal.
Puri	1	15·91	Red oxide of iron.
Santal Parganas	6	21·36	Coal.
Singhbhum	1	41·42	Chromite.
TOTAL	12	..	

TABLE 43.—*Prospecting Licenses and Mining Leases granted in Burma during 1922.*

District.	1922. No.	1922. Area in acres.	1922. Mineral.
Prospecting Licenses.			
Akyab	3	7,288·91	Mineral oil.
Amherst	15	15,219·03	All minerals except oil.
Do.	1	22,822·40	Mineral oil.
Bhamo	1	826·88	All minerals except oil and jade.
Henzada	2	12,800	Mineral oil.
Katha	9	16,128	All minerals except oil.
Kyaukpyu	1	1,280	Mineral oil.
Kyaukse	2	4,655	All minerals except oil.
Lower Chindwin	9	36,754·80	Mineral oil.
Do.	4	22,720	All minerals including mineral oil.
Magwe	25	41,512	Mineral oil.
Do.	1	300	Gold.
Mandalay	1	640	All minerals except oil
Do.	1	640	Iron-ore.
Meiktila	1	23,404	Coal.
Do.	1	1,849·60	Mineral oil.
Do.	1	640	All minerals except oil
Mergui	18	18,861·64	Tin-ore.
Do.	9	6,463·77	Tin and allied minerals.
Do.	15	13,821·29	All minerals except oil.
Do.	4	6,912	Tin and wolfram.
Do.	5	5,419·56	Tin, wolfram and allied minerals.
Do.	3	7,686·72	Coal.
Minbu	8	12,575	Mineral oil
Do.	1	1,920	All minerals including mineral oil.
Myingyan	6	14,515·92	Mineral oil.
Do.	1	1,900·80	All minerals including mineral oil.
Myitkyina	1	640	Silver and copper.
Northern Shan States	1	160	Iron-ore.
Pakokku	14	27,681·35	Mineral oil.
Prome	11	9,808·67	Do.
Shwebo	7	37,759·60	Do.
Do.	5	8,320	All minerals except oil.
Do.	1	960	Coal.
Southern Shan States	1	5,440	Gold, copper and other associated minerals.
Do.	1	640	Gold and other minerals.
Do.	1	84,326	Coal.
Do.	3	21,193	All minerals except oil.

TABLE 43.—*Prospecting Licenses and Mining Leases granted in Burma during 1922*—contd.

DISTRICT.	1922.		
	No.	Area in acres.	Mineral.
Prospecting Licenses—*contd.*			
Southern Shan States	1	640	Red, yellow ochre and black earth.
Do.	2	5,120	Mineral oil.
Do.	1	160	Antimony.
Tavoy	22	10,547	All minerals except oil.
Do.	1	520	Tin and wolfram.
Tharrawaddy	1	640	Mineral oil.
Thaton	1	505·6	Tin.
Do.	2	3,321·60	Tin and wolfram.
Thayetmyo	11	28,066·40	Mineral oil.
Do.	1	448	Coal.
Upper Chindwin	7	29,866	Mineral oil.
Do.	2	4,364	Oil and coal.
Do.	1	1,196·80	Gold.
Yamethin	1	1,100·8	All minerals except oil.
Do.	1	3,200	Petroleum.
TOTAL	249	..	
Mining Leases.			
Amherst	2	1,701·67	All minerals except oil.
Henzada	1	3,840	Coal.
Mergui	2	1,277	Wolfram and tin.
Do.	1	798·72	All minerals except oil.
Pakokku	1	640	Mineral oil.
Tavoy	1	688·87	All minerals except oil.
Thaton	1	235·24	Do.
TOTAL	9	..	

TABLE 44.—*Prospecting Licenses and Mining Leases granted in the Central Provinces during 1922.*

DISTRICT.	1922. No.	1922. Area in acres.	1922. Mineral.
Prospecting Licenses.			
Balaghat	38	17,099	Bauxite.
Do.	23	9,907	Manganese.
Do.	1	532	Copper.
Do.	1	15	Iron-ore.
Do.	2	72	Mica.
Betul	1	156·44	Graphite.
Do.	1	253·54	Mica.
Do.	1	188·26	Iron and ferric oxide.
Do.	17	5,779·98	Coal.
Bhandara	2	51	Manganese.
Bilaspur	1	1,630	Coal.
Do.	1	79·29	Mica.
Chanda	11	7,809	Coal.
Do.	1	251	Bauxite.
Chhindwara	102	23,788·11	Coal.
Do.	9	1,296·15	Manganese.
Do.	1	200	Mica.
Hoshangabad	1	105·4	Coal.
Jubbulpore	9	3,606	Bauxite.
Do.	1	76	Manganese, coal and bauxite.
Nagpur	32	2,528·89	Manganese.
Do.	1	1,082	Coal.
Narsinghpur	1	1,678	Coal, felspar and manganese.
Do.	1	222	Copper.
Saugor	1	75	Iron pyrites, sulphate of iron and sulphur.
Do.	1	1,554	Iron pyrites, sulphate of iron and copper.
Yeotmal	1	461	Coal.
TOTAL	262	..	
Mining Leases.			
Balaghat	8	1,234	Manganese.
Betul	1	1,271·63	Lead.
Do.	7	2,902·02	Coal.
Bhandara	2	110	Manganese.
Bilaspur	1	274	Coal.
Chanda	3	125	Iron-ore.
Do.	2	1,266	Coal.

TABLE 44.—*Prospecting Licenses and Mining Leases granted in the Central Provinces during 1922*—contd.

DISTRICT.	1922. No.	Area in acres.	Mineral.
Mining Leases—*contd.*			
Chhindwara	3	295·19	Manganese.
Do.	20	2,664·25	Coal.
Jubbulpore	1	37·87	Bauxite.
Do.	1	123	Copper, gold, silver, barytes, lead and manganese.
Nagpur	8	351	Manganese.
Yeotmal	3	3,223	Coal.
TOTAL	60	..	

TABLE 45.—*Prospecting Licenses and Mining Leases granted in Madras during 1922.*

DISTRICT.	1922. No.	Area in acres.	Mineral.
Prospecting Licenses.			
Agency Division	2	56,480	Coal.
Anantapur	3	5,694·33	Gold.
Do.	1	1,203·49	Barytes.
Guntur	1	4,270	Diamond.
Karnool	5	26·03	Barytes.
Nellore	6	293·91	Mica.
North Arcot	1	840	Nitrate of copper and allied minerals.
South Kanara	2	451·42	Corundum
Tinnevelly	1	10·03	Do.
TOTAL	22	..	
Mining Leases.			
Nellore	19	568·54	Mica.
Salem	1	4,369	Iron-ore
TOTAL	20	..	

TABLE 46.—*Prospecting Licenses granted in North-West Frontier Province during 1922.*

DISTRICT.	1922.		
	No.	Area in acres.	Mineral.
Bannu	1	1,120	Crude petroleum and its associated hydro-carbons.

TABLE 47.—*Prospecting Licenses granted in the Punjab during 1922.*

DISTRICT.	1922.		
	No.	Area in acres.	Mineral.
Jhelum	3	20,233·60	Mineral oil.
Do.	8	1,110·76	Coal.
TOTAL .	11	..	

LIGNITIC COALFIELDS IN THE KAREWA FORMATION OF THE KASHMIR VALLEY. BY C. S. MIDDLEMISS, C.I.E., F.R.S. (With Plates 28—30.)

INTRODUCTION.

A moderately useful fuel.

THIS brief note is to put on record the quite recent discovery by the Mineral Survey of Jammu and Kashmir State of a low grade, rather impure fuel that may be moderately useful, either in its natural condition for heating purposes, or for distillation for gas, tar, etc. That it has combustible qualities, which under favourable conditions as regards draught and feed enable it to be burnt with success in fireplaces, kitchen ranges, stoves and furnaces, admits of no doubt; and so, like any fuel, it must have a value in a country where all other coal resources are non-existent and where the consequent drain on the forest reserves for firewood is already becoming serious.

Large quantities available.

The localities where it occurs, as so far examined, show that it exists in continuous beds of from 2 feet 6 inches to as much as 6 or 8 feet thick. The few square miles at present surveyed show a certainty of some 30 or 40 million tons down to easily workable levels; but, inasmuch as these embrace two areas forty miles apart, it is not an improbable inference that the lignite beds will be found in disconnected basins co-extensive with the higher south-western border of the Karewa deposits over the greater part of the valley of Kashmir—in which case the quantity available will be very large indeed and such that, except under the most energetic exploitation, cannot well be exhausted in any period we can look forward to.

Only recently recognised.

It might well be considered strange that the Mineral Survey, after 5½ years' work in the State, has only just recently recognised these fuel resources, especially since they lie not far from Srinagar among the gently sloping Karewa deposits, at an elevation of only

from 6,000 to 7,000 feet, and within 10 miles of the flat alluvial valley and its waterways—almost, as one might say, at one's door in Srinagar.

Though vaguely known before.

From current rumours and from occasional observations made in passing through the Karewa zone, it was, indeed, known, in an indefinite way, that some kind of lignite bands or patches occurred in these rocks; but hitherto the summer months of the year have been too much devoted to other mineral investigations, further afield, for time to be given to a subject which then seemed trivial. Another reason which must largely account for this material having remained in obscurity for so long is the external appearance of the bed, which is innocent of any prominent coal-like features. The stuff weathers into a dark grey shaly *débris*, which suggests coal far less than do many other black rocks that are entirely incombustible. Hence the deposits have not attracted general notice. During recent years, however, one hint after another made it inadvisable any longer to postpone the search for this mineral; and so, this late summer (1922), field parties were warned to be specially on the look-out for it during their other investigations.

Discovery and investigation.

The results were two independent discoveries by my Assistants Pandits Sohani Ram and Labhu Ram, which, after specimens were received and examined at head-quarters, appeared to be sufficiently promising for me to pay personal visits to both localities, spending a fortnight at each, and investigating the matter as closely as the advancing season permitted. I was only able to open up the exposures at four localities and to survey quantitatively in detail some few square miles only on the lines which this Survey usually works, that is, by putting the geology on to the 1 inch to 1 mile Survey of India sheets enlarged four times and making more detailed plans of outcrops on the scale of 1 inch to 100 feet. This, however, I trust is sufficient, along with the foot-by-foot samples taken, to insure an accurate picture of these coalfields so far as it goes. Owing to overburden of higher members of the Karewa formation and superficial redistributed glacial and alluvial deposits, forest, soil, etc., it soon became evident that the full extension of these strip-like basins could only be determined with the aid of boring facilities. Hence also the necessarily incomplete and patchy nature of the geological mapping so far done.

The Shaliganga Area.

Description of the area and formation.

This tract lies in Sripartapsinghpura tehsil, near the head-waters of the Shaliganga river, after which it has been named. It lies between latitudes 33° 55′ and 33° 51′ and longitudes 74° 37′ and 74° 41′ and between the elevations 6,500 and 7,500 feet. It comprises the gently sloping country characteristic of the Karewas, lying along the north-east foot of the higher Pir Panjal range. Its central point, near the village of Raithan, is some 15 miles south-west of Srinagar. The Karewa formation was formerly regarded as of lacustrine origin—a deposit of soft sands, loams, clays and occasional conglomerates formed in the valley when it was a dammed up lake and afterwards upraised and cut through by denudation. I have elsewhere (*Rec. Geol. Surv. Ind.*, Vol. XLI, pt. 2, 1911) shown this to be an error except perhaps as regards the uppermost Karewas. The formation is older than the post-Pliocene glacial deposits, beneath which it lies in slightly flexured folds (with dips sometimes amounting to 40 or 50 degrees). In thickness it realises the enormous figure of several thousand feet (the latest estimate being 4,500 feet) and it reaches elevations in the Pir Panjal range of over 11,000 feet. But little has been done as regards its contained organic remains since the work of Godwin-Austen, Drew and Lydekker (summarised by Oldham in the second edition of the *Manual of the Geology of India*) and a description of a few plants collected by myself in the paper quoted above. It is hoped to realize some better collection of remains in the future when the coal beds are developed. Meanwhile it appears certain that these deposits, as conjectured by Oldham in the *Manual* (p. 421), must be much older than post-Pliocene and perhaps should be regarded as near Upper Siwalik in age. They must have swept right over the Pir Panjal range, and so can have no relation to any present valley system or lake basin.

Two synclinal basins and a monocline.

North-east across the gentle folds of this formation the Shaliganga river flows, cutting through two separate, partly delineated, synclinal basins and one monocline, in all of which the lignite is found. Omitting for this occasion any reference to the monocline, which appears at Arigam village and continues in a north-easterly direction with no change, except a gradual lowering in dip, right on to the centre of the valley, there next follows the Narigund anticline,

which is practically barren of lignite, and then we reach the first synclinal basin of Raithan. The Raithan exposures will now be described in some detail, after which I shall proceed on to the third area south-west of this, namely the Lanyalab basin. (See Plate 28.)

The Raithan Exposures.

Raithan syncline.

The synclinal basin to the south-west of the Narigund anticline begins with dips of 40° W.S.W., but this lowers to 20° at the actual coal outcrop. It then lowers still further to the trough of the syncline some 700 feet away, after which the dip is in the other direction, that is N.E. but at very low angles of 3° rising to 7° or 8° along a line of country which itself is inclined in the same direction at about 3°. Thus we have a definite shallow basin here, with the coal bed increasing in depth from the Raithan outcrop to about 150 feet below the present river level, and then decreasing again very gradually to the surface once more.

Detailed plan: Pit No. 1.

The detailed plan of a portion of this area on the scale of 1 inch to 100 feet shows a well exposed bed of lignite outcropping across the middle of a high rocky cliff and continuing to a little promontory overlooking the river where I excavated Pit No. 1. (See Plate 29.) Thence the bed crosses beneath the river to the cliffs at the north side, where it and some other minor beds are exposed again.

Pit No. 1 showed the following section:—

Age		Description	Thickness
Recent		Redistributed Glacial Moraine Material	2 to 3 feet.
		Poor Lignite	6 inches.
		Carbonaceous Clay	6 „
		Grey Sandy Clay	1 foot.
	D	Lignite	6 inches to 1 foot.
	C	Carbonaceous Clay . .	1 foot.
Karewa	B	Tough Sandy Clay . . .	3 feet.
	A 4	Lignite	
	A 3	Lignite	2 „ 4 inches.
	A 2	Lignite	
	A 1	Dark Carbonaceous Clay . . .	1 foot 6 „
		Carbonaceous Clay	Base of section.

Although the upper portion of bed A 1, which is a dark carbonaceous clay with numerous shells of *Planorbis*, burns imperfectly, the lignite series begins really with beds A 2, 3 and 4. It is of an earthy, dark brown to black colour inside with a brown streak. A 2 is a little less massive than A 3 and A 4, but otherwise burns much the same. A 3 and A 4 are strong massive layers of lignite, presenting across the bedding a very tough resistance to ordinary mining tools, but can be hacked through and then levered out with the pick in large slabs, of a size and thickness as much as a man can carry away on his head. These slabs, however, readily splinter along the bedding and then can be further reduced in size with hammers. On drying in the sun, these slabs (as is also the case with all the other lignite beds) crack and curl at the edges with partial separation of the laminæ of bedding, but without any disintegration.

The succeeding bed (B) is a strong and very tough, grey, sandy clay, 3 feet thick, overlain by a carbonaceous clay (C), 1 foot thick. These two beds when tunnelled into present fairly strong walls and roofs that stand easily without any artificial aids, and so will be suitable for affording access to the coal for extraction purposes.

Above this, follows a variable bed of coal of the usual lignitic character (D), of from 6 inches to a foot in thickness. It will yield a useful addition to the coal obtained from the 2 feet 4 inches bed below.

One foot of grey sandy clay follows, then 6 inches of carbonaceous clay and lastly a 6-inch layer of poor lignite. Here the section, so far as the Karewas go, ceases, and nothing more is found except a surface layer of boulders and clay.

Pit No. 2.

Pit No. 2 of the plan is in a 6-inch bed of lignite occurring at a horizon 130 feet above the 2 feet 4 inches bed just described, and there are indications of other similar thin beds at intermediate horizons.

A lignitic series overlain by conglomerates.

These taken all together constitute a lignitic series, and it is immediately overlain by a deposit characterised by the presence of conglomerates. This regular succession, since it is found in the other areas about to be described, may be regarded as establishing a sequence that will be of value for correlation purposes.

The rest of this Raithan synclinal basin is only generally known at present, but, from rough traverses made, it probably has some miles of extension along the strike and is about one mile wide.

The Lanyalab Exposures.

Another synclinal basin.

These occur in the next synclinal basin a few miles to the south-west of Raithan. They embrace a 2 feet 6 inches bed of lignite and a number of other minor beds so far as known. The thickness of the lignitic series is greater here and the dip steeper, being 40°, and over, S.W. or W.S.W. This steep inclination probably only extends a short way (perhaps $\frac{1}{8}$ mile) and then the trough of the fold is reached and followed by the south-west limb of the syncline inclined at low angles to the N.E. or E.N.E. This coal basin will probably be found to be larger than the last, and, inasmuch as great stretches of country are hidden by forest, soil and moraine, there may well be other useful beds of lignite in the series at present unexplored.

Amount of lignite in the two Shaliganga tracts.

For present purposes, as in the case of the Raithan area, I am only reckoning one square mile and a $2\frac{1}{2}$ feet bed (a very conservative estimate). This in the two tracts taken together will yield about 4 million tons for the Shaliganga area. But there is probably very much more. The area is supplied with abundant water and timber and communications with Srinagar, 15 miles away, are easy along a very gently inclined slope.

The Handwara Area.

Locality, altitude, etc.

This area lies in the Uttarmachhipura tehsil, its centre being in latitude 34° 24′ and longitude 74° 8′. It is about 8 miles due west of Handwara (Handawor) and distant some 40 miles from the Shaliganga area. In elevation it is between 6,000 and 6,500 feet. (See Plate 30.)

Karewa formation: one monocline.

The Karewa formation in which the coal seams occur and the general nature of the country are much the same as in the Shaliganga area. The one coalfield so far recognised is in the form of a gently inclined monocline, the rock exposures being fairly continuous over the described area owing to the less development of alluvial and other superficial accumulations at this point.

Rumours of coal here.

Unlike the Shaliganga area, there had been definite rumours of coal in this locality and possibly also petroleum, and, furthermore, the story was current that 50 or 60 years ago the whole countryside had been on fire for a year, during which conflagration the present Maharaja's father had visited it with other State officials, and (the graphic touch is added) that they had their meals cooked over the burning spots. The truth of this rumour is at least supported by the present-day condition of a great many of the outcrops which are obviously burnt to a bright brick red colour.

Coal outcrops.

The coal outcrops are fairly continuous in zig-zag fashion across the area, being the surface expression of a gently dipping bed exposed over an area eroded by stream action. It extends from a point between the villages of Bunar Wadar and Nichahom to Budhashung and Lokut Dardahaj, a distance as the crow flies of 3 miles. It is everywhere overlain by a conglomerate series which apparently is more developed than in the Shaliganga area.

Thickness.

The coal seams are thicker than in that area and are closely set together, so that the total thickness available to one set of workings is well over 8 feet.

Nichahom exposure: vertical section.

One of the best sections seen is in the steep little scarp about ¾ mile S.W. of Nichahom. Here the following vertical section was excavated by my survey :—

M	Sandy bed	5 feet thick.
L 2, L 1	Impure Lignite	2 „ „
K 6, K 5, K 4, K 3, K 2, K 1	Lignite	6 „ „
J	Very tough clay	1 foot 8 inches
H 3, H 2, H 1	Lignitic and carbonaceous clay	2 feet 8 „
G	Grey sandy shelly bed	2 „ 6 „
F	Carbonaceous Clay	0 foot 6 „
E 3, E 2, E 1	Lignite	2 feet 6 „
D	Carbonaceous Clay	0 foot 10 „
C 2, C 1	Lignite	1 „ 10 „
B	Blue Clay (Bottom of section).	6 feet and over.

Quality.

As regards most of this section the lignite appears to be of much the same quality as that in the Shaliganga river area, forty miles away. Its behaviour in burning tests appears to be much the same.

Quantity available.

Allowing for some inferior bands such as H and L in the above section, a very safe estimate of 8 feet thickness altogether is taken by me. The area over which at present this may be presumed to extend to easily workable depths I similarly estimate at 5 square miles. This will give a total of 32 million tons. A great deal of this, from the lie of the country, will be above ground water level, and a certain area near Nichahom will lie close under the surface and might be worked opencast.

The Pohru river at Handwara, which falls into the Jhelum at Sopor, is navigable for boats during most of the year, so that the coal area is within 8 miles of easy connection with the rest of the valley.

Composition : Burning Tests.

Proximate Analyses.

From what has been said in the previous paragraphs, it will be clear that a considerable tonnage of this fuel can be confidently anticipated from the small areas so far delineated ; also that these areas are probably only a fraction of what actually occurs, yielding coal in intermediate and outlying places among the Karewa deposits in the Kashmir valley. There is thus an ample supply of the material. The only question now to be considered is its quality, and whether or not it can be profitably utilized in any of those ways in which such fuels are ordinarily made use of.

Moisture.

From a number of proximate analyses of the lignite, made by the Mineral Survey in Kashmir, and in the Geological Survey of India laboratory by the kindness of the Director, the contained moisture was found to vary between the wide limits of 8·6 per cent. and 33·43 per cent. It appears that ordinary exposure in the air, such as is incident to its extraction and manipulation during testing, causes this wide difference according to climatic changes. An average of about 15 per cent. in the climate of Kashmir may be taken as approximately correct. This percentage, on transmission of the material in bags to Jammu in the dry air of the Punjab, became reduced to 10 per cent. whilst, on transmission to Calcutta, it became increased to

nearly 30 per cent. This is well shown in the table of analyses given below, which were made in Calcutta.

Ash : Combustible matter.

The ash content in ordinary bulk samples, in Kashmir, free from surface dust and impurities, comes out fairly uniformly in all the assays as about 30 per cent. This leaves 55 per cent. combustible matter, but the distribution of this under the heads of fixed carbon and volatile matter is not quite simple.

Analyses of Lignite.

—	Lanyalab A. bed.	Nichahom Lower bed.	Nichahom Upper bed.	Raithan Pit No. 1 A. bed.	Raithan Pit No. 1 D. bed.	Raithan Pit No. 2.
	1	2	3	4	5	6
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture . .	28·41	33·42	32·85	26·27	26·86	29·52
Volatile matter	25·98	30·61	29·69	27·71	29·98	31·88
Fixed carbon .	15·09	18·34	16·22	19·00	19·70	21·62
Ash . . .	30·52	17·62	21·24	27·02	23·46	16·98
	100·00	100·00	100·00	100·00	100·00	100·00
	Does not cake.	Does not cake.	Does not cake.	Does not cake.	Does not cake.	Does not cake.
	Ash, reddish brown.	Ash, brown.	Ash, reddish brown.	Ash, brown.	Ash, brown.	Ash, brown.
Calorific power in heat units (C) . .	3,822	4,034	2,714	2,714	3,154	2.274
Evaporative power . .	(By bomb calorimeter)	7·51	5·05	5·05	5·87	4·23

Ratio of fixed carbon to volatile matter.

All proximate analyses of coal, according to the method adopted, vary in the results obtained as regards the ratio of fixed carbon to volatile matter. The distinction between the two is recognised as being very arbitrary; but it would appear that the Kashmir lignite is especially sensitive to variations in the method adopted, and the ratio, fixed carbon to volatile matter, shows great variations accordingly. The data obtained in Kashmir gave this ratio (fuel ratio) as from 1·24 (Mineral Survey) to 0·94 (Mr. Bose of the Prince

of Wales College, Jammu) where the method adopted was approximately that given in Beringer's "Text-book of Assaying," 12th Edn., 1910. The results obtained in the Geological Survey of India laboratory, where the standard method as used in the Geological Survey of England was adopted, gave the fuel ratio as much less, namely, 0·63. In view of these discrepancies Dr. Pascoe kindly had estimations repeated in the Geological Survey laboratory in an atmosphere of nitrogen, with results that gave an average of 6·6 per cent. less volatile matter than that furnished by the standard method, thus making the fuel ratio about unity.

Average composition.

Consequently, perhaps we shall not be far wrong in stating the composition of the Kashmir lignites to be on the average as follows :—

Moisture	15	per cent.
Ash	30	,, ,,
Volatile matter	28	,, ,, (determined in an atmosphere of nitrogen).
Fixed carbon	27	,, ,, (by difference).
	100	

Calorific power.

Estimations of the calorific value of six samples of the lignite made in the Geological Survey laboratory gave :—

Calorific power in calories . .	from 4,034 to 2,274 (average 3,119).
Evaporative power	from 7·51 to 4·23.

The above determinations were done in L. Thompson's calorimeter.

Summary of chemical data.

Considering the data arrived at above, it appears that the Kashmir lignite, except for the high ash content, must rank as an ordinarily good lignite, such as the brown-coals of the Bohemian main basin, and much better than those of Saxony with moisture from 40 to 60 per cent. It is hoped that the high ash percentage will be reduced in some measure when excavations to the deep, away from the outcrop, are made. It is this high ash percentage that is mainly responsible for the lignite being difficultly combustible and not the 15 per cent. moisture, which represents the ideal lowest limit attained in the manufactured brown-coal briquettes in Germany.

That the ash percentage may be reduced away from the outcrop seems indicated by small variations already noticed to distances of 10 or 20 feet only from the outcrop. Stacking the lignite in the

sun in the dry atmosphere of Kashmir will also reduce the moisture to less than 10 per cent. This will be effected also without any noticeable disintegration of the material, which, so far as at present observed, retains its consistency (about that of a hard ship's biscuit) in all conditions of atmosphere completely unimpaired.

Burning Tests.

As regards actual burning tests, I cannot as yet produce any results of systematic tests undertaken with proper precautions and on an adequate scale. I can, however, say, that out of the several tons of the coal brought away from the cuttings, I have distributed a considerable quantity to engineers and other ordinary householders in Srinagar to try in their fireplaces, stoves, etc., and that in most cases where I have received a report it has been favourable and often enthusiastic.

I may summarise these results and the results attained by my own test experiments as follows :—

(1) The material is clean, easy to handle, travels well without disintegrating, so that there is no need to have recourse to briquetting, a custom that is so general with soft earthy lignites, in order to get rid of the excess of moisture and to make it easy to handle.

(2) It burns best in English grates with bars and a good draught.

(3) It is necessary to start the fire with wood and get it going nicely before the coal is fed on to it.

(4) The ash is soft and pastry-like, clinkering being absent or unimportant except with a powerful draught.

(5) Once well started, the coal burns without any smoke and with a low blue flame, as if spirits of wine were burning.

(6) Means for getting rid of the large amount of ash are essential from time to time, otherwise the fire dies down by the clogging of the air passages through the bars.

(7) Used in this way it makes a very effective and pleasant fire for domestic purposes, and certainly economises the wood fuel now in general use in Kashmir. Used with some wood it is an ideal house fire.

(8) Used for other purposes in furnaces, the provision of special grates in order to apply the feed in such a way that the large amount of ash can be coped with, must be regarded as absolutely necessary.

A considerable future for the coal.

The above results of experiments seem to show that there may be a considerable future for this lignitic coal in Kashmir where it has no other competitor except wood; but whether, owing to modifications in quality to the deep, or to adequate feed arrangements, it will have a greater usefulness in furnaces for raising steam, in smithies and so on, is a point as yet entirely undecided.

Early Accounts of the Lignite.

Sir Aurel Stein has drawn my attention to some early accounts of underground fire phenomena in the Nichahom lignite locality. Others have been discovered by my colleague Lala Joti Parshad. Although some of these have attributed the phenomena wrongly to volcanic agency, the main interest of them lies, I think, first in the bare fact that fires emanating from fissures seem undoubtedly to have occurred in this area from time to time; and secondly because of the recorded connection between these conflagrations and earthquake shocks. Earthquakes frequently produce superficial fissures at the free edges of loosely consolidated formations such as the Karewas, and fissures of that kind would be the natural channel for the escape of inflammable gases generated in the lignite beds.

Historical References.

An extract from Kalhana's "Chronicle of the Kings of Kashmir" translated and annotated by Sir A. Stein (London, A. Constable & Co., 1900), page 7, text I, verse 34, is given below:

"There the 'self-created fire' (Svayambhu), rising from the wombof the earth, receives with numerous arms of flame the offerings of the sacrificers."

NOTE.—Svayambhu, or in the language of the villagers *Suyam*, is the name of a spot, situated half a mile to the south-west of the village of Nichahom, circ. 74° 10′ long., 34° 22′ lat., in the Machipur Pargana, where volcanic phenomena are observed in a shallow hollow formed between banks of clay and sand. In certain years vapours issue here from fissures in the ground, then sufficiently hot to boil the Sraddha offerings, which the pilgrims place there. When I visited the site in September, 1892, the phenomenon was said not to have taken place for the last fifteen years. But the soil of the hollow appeared even then bright red, like burned clay, and was furrowed by narrow fissures. P. Govind Kaul attended a pilgrimage to Svayambhu in the year 1876, when the symptoms were noticeable for about ten months. Vigne, "Travels", ii, p. 280, mentions occurrences of the phenomenon at the beginning of the present century. For an earlier reference, see "Ain-i-Akbar", ii, p. 365; comp. also Lawrence, "Valley", pp. 42, sq.

The Svayambhumahatmya relates at length the legend how Siva (Svayambhu), at the request of the gods who were hard pressed by the Asuras, took there the incarnation of Kalagnirudra ; comp. also "Nilamatap", 1040.

A pilgrimage of King Uccala to Svayambhu is mentioned by K., viii, 250.

The reference to "Ain-i-Akbar" given above may be translated roughly as follows :—

In the sub-division of Kamraj after the lapse of a few years the earth shakes and the ground in some places breaks and from a small fissure fire appears. On that fire, water with rice in a bowl is put and the contents cooked. In spite of this, vegetation, trees, rivers, etc., flourish in their proper condition in the place.

Mr. Roy's report.

The diary report of Mr. H. Roy, Mining Engineer, submitted to the late Raja Sir Amar Singh in 1904, gives an account of a large number of outcrops of lignite visited by him in the Handwara neighbourhood, some of which he described as impure lignite and some as good coal. In regard to the Nichahom occurrence he correlates it with the locality mentioned by Lydekker in his "Geology of Kashmir" (*Mem. Geol. Surv. Ind.*, Vol. XXII, 1883, p. 43) quoting a brief remark by Dr. Hugh Falconer (*Pal. Mem.*, Vol. I, p. 567, note), but which occurrence was wrongly attributed to subterranean volcanic action by both these observers.

Mr. Roy gives the correct explanation ; but, in discussing how the material came to be ignited by some form of spontaneous combustion, he has neglected the more probable cause, namely, surface fires of dry grass and leaves, started by human agency, which commonly happen in the hills in the hot weather.

EXPLANATION OF PLATES.

Plate 28.—Map of part of the Shaliganga Coalfield : Scale, 4 inches = 1 mile.
,, 29.—Plan of the Raithan Coal outcrops : Scale, 1 inch = 100 feet.
,, 30.—Map of the Handwara Coalfield : Scale, 4 inches = 1 mile.

BASIC AND ULTRA-BASIC MEMBERS OF THE CHARNOCKITE SERIES IN THE CENTRAL PROVINCES. BY K. A. KNIGHT HALLOWES, M.A. (CANTAB.), F.G.S., A.R.S.M., F.R.M.S., *Assistant Superintendent, Geological Survey of India.* (With Plates 31 to 33.)

Introduction.

SINCE Sir T. H. Holland established the Charnockite Series in South India[1] these rocks have been met with in several other localities both within and without the limits of the Indian Empire.

T. L. Walker found members of the basic group of this series in the Kalahandi State,[2] and also in Ganjam and Vizagapatam; they have also been met with in Mourbhanj by the geologists of the Tata Iron and Steel Co., Ltd.[3] Lacroix has described quartz-norites belonging to the basic group of the charnockites from the Ivory Coast, French Guinea and Liberia.[4] J. W. Gregory discovered norites in West Africa which he believed to be intrusive into the schistose quartzites of the area, as they contain many hornfels inclusions[5]; G. W. Tyrell who submitted them to microscopic study classifies them as hornblende-augite-norites belonging to the basic group of the Charnockite Series.[6]

Occurrences in the Central Provinces.

Basic and ultra-basic members of the series were found by the writer intrusive into hornblende and biotite gneisses, during field season 1917-18, at several points along the Wainganga valley in the districts of Balaghat, Bhandara and Chanda. (See Figs. 1 and 2.) The localities are as follows[7] :—

(*a*) *Biotite norites*.—Bamori, Balaghat, [13,385]; the occurrence (21° 46′ 12″ : 80° 13′ 30″) is situated about 700 yards W.S.W. of

[1] *Mem. Geol. Surv. Ind.*, Vol. XXVIII, pt. 2, (1900).
[2] *Ibid*, Vol. XXXIII, pt. 3, p. 7, (1902).
[3] *Rec. Geol. Surv. Ind.*, Vol. XXXIX, p. 110, (1910).
[4] "Sur l'existence à la Côte d'Ivoire d'un série pétrographique comparable à celle de la charnockite." *Comptes Rendus*, Vol. CL, pp. 18-22, (1910).
[5] "Contributions to the Geology of Benguella." *Trans. Roy. Soc. Edin.*, Vol. LI, pt. III, p. 516, (1917).
[6] "A Contribution to the Petrography of Benguella, based on a collection made by Prof. J. W. Gregory, F.R.S." by G. W. Tyrell. *Trans. Roy. Soc. Edin.*, Vol. LI, pt. III, p. 540, (1917).
[7] The figures in round brackets are the registration numbers of the rock specimens in the collections of the Geological Survey of India while those in square ones refer to the rock sections.

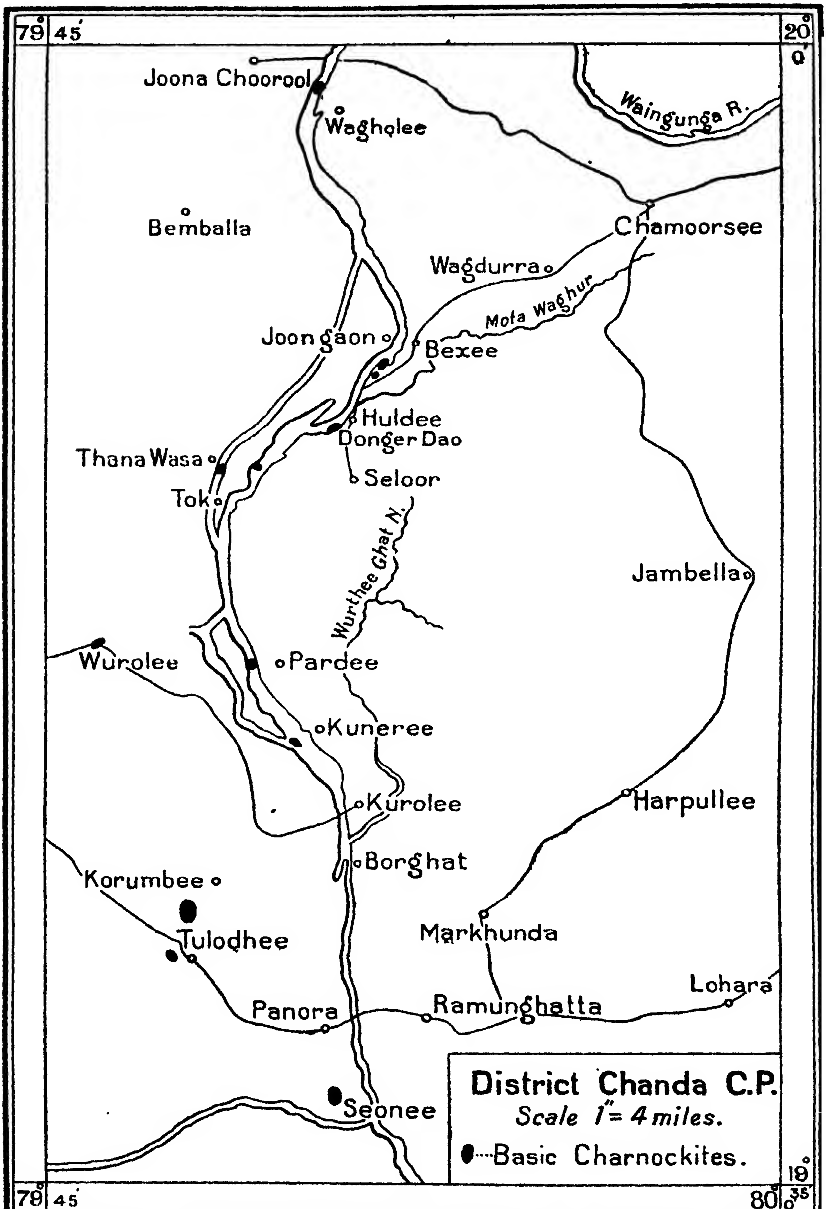

FIG. 1.—Basic Charnockite localities of the Chanda District.

this village, on the south bank of the Wainganga River, the exposure extending for a distance of several yards.

(*b*) *Augite norites* :—Saonra, [13,386], (see Pl. 32, fig. 2); Waghole, (29·632), [13,388]; Joongaon, [13,389]; Pardee, (29·631), [13,390]; Kuneree, [13,391]; Seonee, (29·633), [13,392].

(*c*) *Garnetiferous-augite-norites* :—Bondranee, [13,393]; Boregurh, [13,394]. (See Fig. 2.)

(*d*) *Hornblende-augite-norites* :—Tullodhee, [13,395]; Tamnee (29·630), [13,387].

(*e*) *Pyroxenites* (ultra-basic group of the Charnockite Series) :—Korumbe, [13,396]; Wurolee, [13,397]; Donger Dao, Huldee, (29·662), [13,398]. (See colour-photo-micrograph Pl. 31); and Thana Wasa, [13,399].

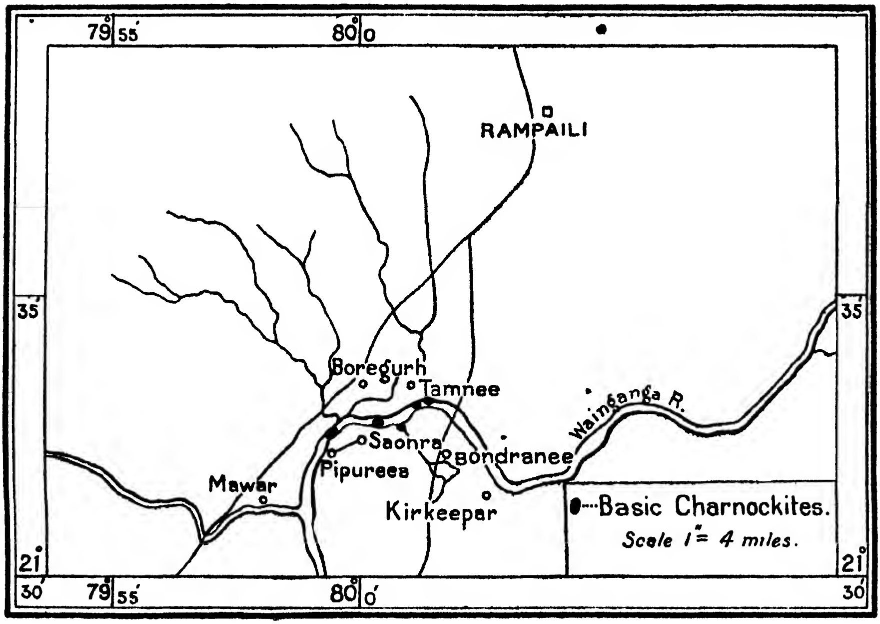

FIG. 2.—Positions of certain localities in the Wainganga Valley.

The rocks are composed of the following minerals: hypersthene, monoclinic pyroxene, felspar, quartz, garnet, biotite, hornblende, apatite, and iron pyrite.

Hypersthene.

The hypersthene, as seen from slices [13,387], [13,392], and [13,399], shows straight extinction, and has, in slide No. 13,392, a pleochroism which varies from pale brownish-pink to pale bluish-green. It alters to a green fibrous mineral which resembles delessite, contains large square or oblong, tabular inclusions of red iron oxide, [13,391], [13,395], and is occasionally intergrown with monoclinic pyroxene, [13,392]. In the garnetiferous-augite-norites, the ground-mass is composed of a mosaic of plagioclase and a little quartz. As Sir Thomas Holland remarked in the case of his specimens from Madras,[1] the hypersthene and the garnet, [13.393], (see Pl. 32, fig. 1), are of the same pale pink colour, the former being distinguishable by its strong pleochroism.

Monoclinic-pyroxene.

The monoclinic pyroxene, [13,392], is very feebly pleochroic and has a wide angle of extinction; it is probably diopside. Occasionally, granules of this mineral have been largely replaced by a green decomposition product, [13,390], which appears to be uralitic hornblende; in some of the ultra-basic charnockites or pyroxenites the augite, [13,398], has a schiller structure like that of diallage.

Felspar.

The felspar comprises orthoclase or an unstriped plagioclase in Carlsbad twins, [13,392], microcline, [13,385], and a plagioclase [13,395], approaching labradorite. The pyroxenites have little or no felspar. That of Kuneree, [13,391], contains a little interstitial plagioclase while that of Thana Wasa, [13,399], is composed of pale green diopside and hypersthene, and is entirely free from felspar.

Quartz.

Quartz, as in the typical basic charnockites of Madras, is frequently intergrown with the felspar of the augite-norites, [13,385]. It sometimes occurs, [13,388], as "quartz de corrosion," and, with its dark purplish clouds of minute inclusions, is seen in small amount in the interstices between the minerals of the pyroxenite of Wurolee, [13,397].

Garnet.

The garnet of the garnetiferous-augite-norites, [13,393], sometimes forms a corona which partly surrounds a grain of hypersthene. It is, however, not

[1] *Op. cit.*, p. 161.

spongy like that which circles the hypersthene of the garnetiferous basic charnockite of Nagaramalai near Salem, Madras.[1] Occasionally, [13,393], the garnet half surrounds a more or less circular mosaic of quartz, whose remaining semicircle is zoned with pale green monoclinic pyroxene. The garnets, [13,393], contain no acicular inclusions like those mentioned by Holland in the garnetiferous charnockites of Nagaramalai.[2]

Biotite.

Biotite in fair quantity occurs in some of the norites, [13,385], [13,388]. In the augite-norite of Seonee, [13,392], this mineral is seen in ragged flakes which exhibit very strong absorption, varying from a pale yellowish to a deep reddish-brown.

Hornblende.

The hornblende of these rocks appears to be all secondary. In the hornblende-augite-norite of Tullodhee, [13,395], brownish-green secondary hornblende, derived from the original pyroxene, and exhibiting the characteristic lozenge-shaped cleavage, occurs. Sometimes, [13,387], (see Pl. 33, fig. 1), the secondary hornblende is pale golden-brown in colour, with a greenish tinge, still remaining unaltered cores of diopside being seen within it. The pyroxenite of Korumbe, [13,396], contains a secondary, brown, pleochroic hornblende into which the original pyroxene has passed, that of Wurolee, [13,397], has a golden-brown, strongly pleochroic secondary hornblende, while that of Donger Dao Huldee, [13,398], exhibits one which is pale greenish-yellow-brown in colour.

Apatite and Iron pyrite.

Apatite occurs in grains in the augite-norites of Seonee, [13,392], and Waghole, [13,388]. It is found also in short columns with straight extinction in the augite-norites of Waghole, [13,388], and Joongaon, [13,389]. The mineral is, moreover, seen in the biotite-norite of Bamori, [13,385]. Iron pyrite, which is very rare in these rocks, occurs in the form of granules in the pyroxenite of Thana Wasa, [13,399].

Comparison with Madras.

The charnockites of the Wainganga valley described above are almost identical with the types from Madras, although, from the rarity of the quartz, they seem to be slightly more basic.

[1] *Op. cit.*, Pl. VIII, fig. 6, and *Mem. Geol. Surv. Ind.*, Vol. XXX, p. 125.

[2] *Mem. Geol. Surv. Ind.*, Vol. XXX, p. 127.

EXPLANATION OF PLATES.

Plate 31.—Colour-photomicrograph of Pyroxenite; polarized light; × 17 : [13,398].

,, 32.—Fig. 1.—Photomicrograph of Augite-norite: ordinary light; × 17 : [13,393].

,, 32.—Fig. 2.—Photomicrograph of Augite-norite; polarized light; × 32 : [13,386].

33.- Photomicrographof Hornblende-augite-norite; ordinary light; × 32 : [13,387].

THE CHINA CLAY OF KARALGI, KHANAPUR, BELGAUM DISTRICT. BY K. A. KNIGHT HALLOWES, M.A. (CANTAB.), F.G.S., A.R.S.M., A.INST.M.M., *Assistant Superintendent, Geological Survey of India.*

MR. E. R. Fern, Superintendent of the Pottery Department of the School of Art, Bombay, having observed kaolin near Karalgi, Taluka Khanapur, Belgaum District, I was deputed in November 1920 to investigate the occurrence. A number of prospecting shafts were sunk at the locality and chemical and physical tests made on samples from the field by Mr. Fern; these will be found tabulated on page 265.

The occurrence seems to have been missed by Bruce Foote in his survey of the South Mahratta Country: he merely remarks that " a kind of granitoid gneiss runs through the town of Khanapur."[1]

Occurrence.

The kaolin, as will be seen from the plan (Fig. 2), occurs in the side of a natural hollow the axis of which strikes north-east and south-west. The lateritic soil has been washed away by rain and the white china-clay exposed; it passes gradually through kaolinised into unaltered gneiss. At its actual junction with the overlying kaolinised gneiss, the white clay is very impure and iron-stained, being of an ochre yellow colour; it becomes, however, purer and whiter at lower and lower horizons, until, finally, in the trial shaft No. 1, it passes into pure white china-clay. The locality (Revenue Survey, Sheet No. 76) is situated some three miles from the railway station at Khanapur. (See map, Fig. 1.)

Completely unaltered gneiss was not observed in any of the trial shafts, but exposures of it were seen in a field adjoining shaft No. 1, and at a point in the Malprabha river near by. In the latter locality, a short distance north-west of shaft No. 1, are beds of schistose gneiss forming a bar across the river; these are traversed by a series of joint planes with an inclination of 50° in a W.S.W. direction. North-east of shaft No. 1, and in the east bank of the same river, just beyond the bend which it makes to flow northwards after

[1] *Mem. Geol. Surv. Ind.*, Vol. XII, p. 43, (1876).

pursuing an easterly direction, and not far from the point where it is joined by a small tributary, is an exposure of gneiss, the felspars

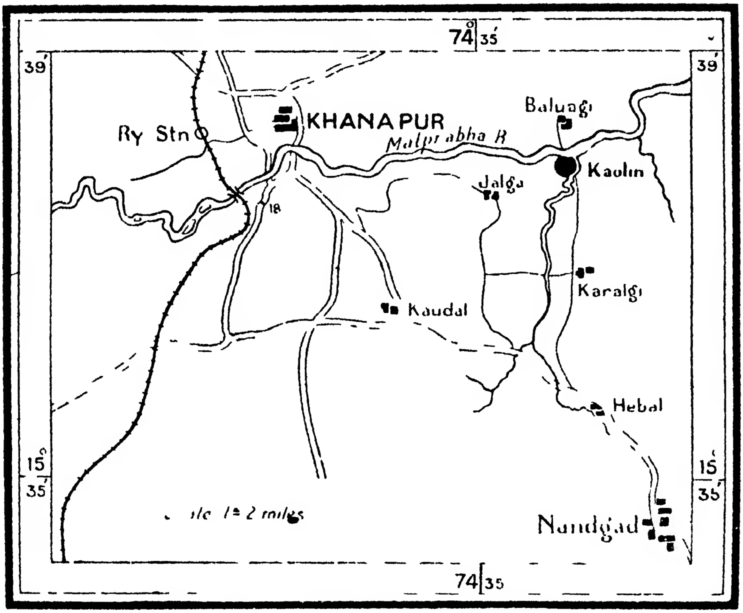

FIG. 1.—Map showing position of the kaolin deposit

of which can be seen with the unaided eye to have been partly altered into kaolin. Except for these exposures of the underlying gneiss, the country in the vicinity of the kaolin occurrence at Karalgi is covered by alluvium. In the midst of the china-clay itself are fragments of slightly decomposed gneiss, the outer surfaces of which have been altered into kaolin; these indicate clearly that the china-clay has been formed by the kaolinisation of the gneiss. The kaolin in shaft No. 1 was derived from the muscovite-gneiss underlying the lateritic capping, and contains here and there flakes of white muscovite, which escaped alteration when the felspars were decomposed.

In shaft No. 4 it is noticeable that the kaolinisation of the gneiss gradually decreases with increase of depth, a result to be expected if the kaolinisation is, as believed, brought about by carbonated surface waters.

The brown colour of some of the kaolin, which vanishes on heating, points to this mode of origin, and is due to the *humus*

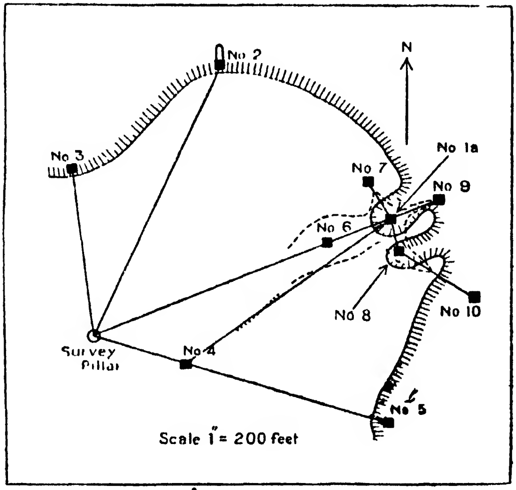

FIG. 2.—Plan of kaolin deposit showing numbered trial shafts.

introduced by the percolating, organic acid-bearing, surface waters. The latter have acted on the felspars of the gneiss in the usual way :—

$$2KAlSi_3O_8 + 2H_2O + CO_2 = H_4Al_2Si_2O_9 + 4SiO_2 + K_2CO_3$$

(Felspar) (Carbonated surface waters) (Kaolin)

These waters have continued to circulate through the cracks in the felspars for such long periods of time, that the kaolinisation, starting from the margins of the cracks, has eventually transformed the whole substance of the crystals into kaolin. Neither in the kaolin nor in the gneiss into which it gradually merges, were to be found any of the usual minerals produced by pneumatolysis, such as tourmaline, fluor-spar, fluor-apatite or topaz; consequently these deposits cannot be regarded as equivalent to some of the kaolin deposits of Cornwall which contain these minerals, the kaolinisation of the Cornish granite having been brought about by hydrofluoric and boric acid vapours.

Quantity.

To determine the thickness and horizontal extent of the mass of kaolin and to ascertain to what degree the country rock had become kaolinised, ten trial

shafts were sunk. In No. 1, the kaolin is 11 feet 7 inches thick, and extends underground in a south-south-easterly direction to shaft No. 8, where it increases to a thickness of 17 feet.

In the following table will be found details of the trial shafts sunk :—

Table of the Prospecting Shafts at Karalgi.

Number of Shaft.	Total depth from surface.	Depth of the upper limit of the Kaolin from the surface.	Depth of the lower limit of the Kaolin from the surface.	Thickness of the bed of Kaolin.	Nature and thickness of the "Over-burden."	REMARKS.
No. 1	20′ 3″	8′ 8″	20′ 3″	11′ 7″	Granular laterite :— 4′ 10″.	A lenticular bed of excellent kaolin suitable for the manufacture of chinaware. The kaolin is very free from grains of quartz and felspar except near the lower limit of the bed. At the bottom of the prospecting shaft the lower surface of the lenticular bed of kaolin dips towards No. 8; it was subsequently found to have increased in thickness to 17′ 0″ in the latter shaft.
,, 2	Pit = 6′ 4″; the attached trench = 6′ 6″	..	..	A few minute stringers of partly kaolinised gneiss.	Soil and decomposed gneiss.	The prospecting trench attached to the shaft strikes N. 70° E.; it shows decomposed gneiss with occasional minute stringers of white, partly kaolinised gneiss.
,, 3	10′ 6″	..	..	Do.	Do.	The bed of kaolin, which is 11′ 7″ thick in shaft No. 1, has thinned out entirely before reaching shaft No. 3.
,, 4	25′ 10″	14′ 0″	24′ 8″	10′ 8″	Granular laterite :— 2′ 8″.	The shaft is sunk on the bed of kaolin. At its lower end, against the west wall, is kaolin of very good quality, similar to that in Pit No. 1. This bed of kaolin is seen in the shaft to pass down by gradual transition into partly kaolinised gneiss, which grades, at a lower horizon, into almost unaltered pink gneiss.
,, 5	8′ 0″	..	..	A few minute stringers.	Soil and decomposed gneiss.	The bed of kaolin, 11′ 7″ thick in shaft No. 1, has thinned out entirely before reaching Pit No. 5.

Table of the Prospecting Shafts at Karalgi—contd.

Number of Shaft.	Total depth from surface.	Depth of the upper limit of the Kaolin from the surface.	Depth of the lower limit of the Kaolin from the surface.	Thickness of the bed of Kaolin.	Nature and thickness of the "Overburden."	REMARKS.
No. 6	24′ 3″	18′ 0″	. .	More than 6′ 3″.	Granular laterite :—6′ 0″.	The upper boundary of the bed of kaolin in this shaft slopes slightly to the west; the kaolin contains fragments of quartzite, and is not of such good quality as that in prospecting shaft No. 1.
,, 7	19′ 7″	. .	. .	A few minute stringers.	Do 4′ 2″	Between the surface and a depth of 10′ the gneiss is decomposed into a dark yellowish-brown clay, while between the horizons of 10′ and 19′ 6″ the gneiss is fairly fresh and contains stringers of kaolinised gneiss.
,, 8	22′ 4″	4′ 4″	21′ 4″	17′ 0″	Soil and decomposed gneiss 2′ 10″.	This shaft is sunk in the middle of a natural hollow in the ground. The kaolin is very pale sea-greenish-white in colour.
,, 9	6′ 9″ .	. .	. .	A few stringers of white kaolin.	Do. .	The bed of kaolin, 11′ 7″ thick in shaft No 1, when traced for 56′ in a north-easterly direction, thins out into a few worthless stringers of gritty kaolin in prospecting shaft No. 9
,, 10	7′ 0″	.	.	A few minute stringers of pale sea-green kaolin.	Do. .	The bed of kaolin, 17′ 0″ thick in shaft No 8, thins out almost entirely in Pit No. 10.

These shafts show that the thickness (see Fig. 3) and quality varies from point to point, the bed consisting at one place of

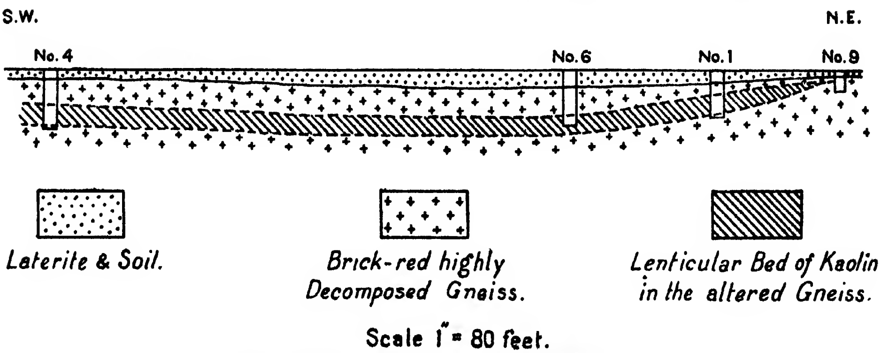

Fig. 3.—Section across the kaolin deposit

almost pure kaolin, and at another of gritty, partly kaolinised gneiss.

The trial shafts proved the presence of kaolin to the order of 4,000 tons, but a reliable estimate of the total is impossible without further prospecting.

Quality.

As will be seen from the table below, the kaolin of this locality is of good quality; and it has to be added that all five samples were non-plastic, and did not crack on drying, or on firing to 1,050°C. At 1,300°C. the material in every case was soft and porous, with no signs of fusion, and of a very pale cream or almost white colour.

Table of the Analyses and Physical Properties of the Kaolin of Karalgi.

Locality.	CHEMICAL COMPOSITION. SiO_2	Al_2O_3	Fe_2O_3	CaO	Loss on Ignition.	Fine clay produced after levigation.	REMARKS.
	per cent.	per cent.	per cent.	per cent.		per cent.	
Kaolin from prospecting shaft No. 1.	44·9	39·1	1·5	2·5	11·7	35·8	*Slightly creamy colour.* May be employed for the manufacture of common china and earthenware and as sizing material for cloth. Of no use for modelling as it is not plastic.
Do. No. 4	44·0	41·3	0·5	1·5	11·9	19 15	*White.* May be used for the manufacture of good china and porcelain and as sizing material of good quality for cloth and paper making.
Do. No. 6	45·5	38·4	2·1	2·3	11·1	17·95	*Nearly yellow in colour.* Not of much use for pottery or porcelain except for the very lowest and cheapest grades. Of no value as a sizing material.
Do. No. 8	44·2	41·5	1·5	1·0	11·9	16·75	*Light cream coloured.* Will serve the same purposes as the kaolin of prospecting shaft No. 1.
Kaolin from near prospecting Shaft No. 1.	45·0	39·0	1·5	3·0 Traces of MgO.	11·0	..	*White.* Do

Analyses by Mr. E. R. Fern, Superintendent, Pottery Department, School of Art, Bombay.

The china-clay of shafts Nos. 1, 4, 6 and 8 approximates to kaolinite, $Al_2O_3\ 2SiO_2\ 2H_2O$; (SiO_2 = 40·8 per cent., Al_2O_3 = 39·8 per cent.). The 1·5 per cent. of Fe_2O_3 in shafts Nos. 1 and 8 causes the clay to burn a pale yellowish-white, while the 2·1 per cent. of Fe_2O_3 in the kaolin of shaft No. 6 gives a buff product after firing ; the lime present in the latter, however, diminishes the depth of colour. The quality of the kaolin, so good in shafts Nos. 1 and 8, falls off in No. 6, but becomes better in No. 4 than it was in No. 1. The analyses also indicate that the quality in No. 1 is maintained in a S.S.E. direction into No. 8.

The quality of the Karalgi kaolin compares favourably with that of Patraghatta Hill on the Ganges, Rajmahal, which was successfully used for several years to manufacture china-ware of good quality in a pottery works ; the analysis of this showed 55-57 per cent. SiO_2 ; 39·11—40·38 per cent. Al_2O_3 ; a trace of Fe_2O_3 ; 1·42—2·20 per cent. CaO ; and 10—14 per cent. loss on ignition.

A washed sample of kaolin from shaft No. 1 was sent to Messrs. C. N. Wadia & Co., Century Mills, Bombay, who were good enough to make with it a "full sizing test". Mr. J. G. Anderson, General Manager of the Mills, reports that the kaolin is somewhat inferior to the china-clay which they import from home for sizing yarn, as the latter is less brittle and a little whiter in colour. He points out, however, that the whiteness of the kaolin could be improved by sun-bleaching, and by treatment with a trace of blue colouring matter, and that its brittleness could be remedied by the addition of a little glycerine, although this treatment would, of course, somewhat increase its cost. He concludes from his tests, that the kaolin is more suitable for finishing cloth than for sizing yarn, as in the former process, ingredients are added to whiten the cloth, which would neutralize to some extent the objectionable tint of the clay. He draws attention to the fact that it has better adhesive qualities than the kaolin imported from England.

Exploitation.

At Karalgi water for levigation purposes is obtainable from the Malprabha ; even in the hot weather this river contains water, although in much diminished quantity. From the table on page 265 it is seen that the kaolin of shaft No. 1 gives 35·8 per cent. of fine clay after levigation. This compares favourably with the kaolins of other localities in the Indian Empire. The kaolins of Kyauktat and Kabauk in Upper Burma, on examination by the writer in 1919, gave, on levigation,

33 per cent. and 25 per cent. of fine clay respectively, while the kaolin of Mangal Hat in the Sontal Perganas, employed by the Calcutta Pottery Works for the manufacture of china, gives 23·4 per cent. of refined kaolin.

The railway at Khanapur is only 3½ miles due west, in a straight line, from the kaolin at Karalgi; connection might be made by a light tramway.

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HENRY HUBERT HAYDEN: BORN JULY 25TH 1869. DIED AUGUST 1923.

IT is with the greatest regret that I have to record the death of Sir Henry Hubert Hayden, C.S.I., C.I.E., B.A., B.A.I (Dub.). D. Sc. (Calcutta), F R.S., F.G.S., F.A.S.B., formerly and recently Director of the Geological Survey of India. Educated in Natal and in Dublin University he joined the Geological Survey of India on the 21st February 1895. In addition to his usual duties he was appointed Curator of the Geological Museum and Laboratory on the 1st January 1897, and from the 27th November 1902 till the 23rd February 1903 he acted as Superintendent of the Indian Museum; on the 25th February 1903, he was promoted to Deputy Superintendent, and on the 2nd May 1901 to Superintendent; on the 1st December 1910 he was appointed Director, and after being accorded the official honours of C.I.E. in 1911 and C.S.I. in 1919, received the honour of Knighthood on his retirement from service on the 1st June 1921, for his valuable services to this country.

Sir Henry Hayden was a great traveller and his name will, for all time, be associated with the geology of the Himalaya and of Tibet. He spent his first camp season in Burma investigating the occurrences of statuary marble, rubies, sapphires and spinels of the Mandalay district and Sagyin Hills, examining the coal outcrops of Mithwe in Bhamo, exploring the extinct volcano of Mount Popa, and making a traverse across the unhealthy Arakan Yoma to the steatite quarries of Hpa-aing. In 1897-98 he was attached to the Tirah Expeditionary Force and afterwards published a short Memoir on the result of his work. Subsequent activities included an

exhaustive and illuminating survey of Spiti and Lahaul where he discovered the now classic section of Cambrian rocks; an examination of the mica mines of North Hazaribagh; a survey with Dr. Hatch of the gold deposits of Wynaad; an examination of the railway hill section around Haflong in Assam; a journey to the Palni Hills; a survey of various glaciers in Kashmir; a survey of the oil and coal fields of Upper Assam and the Naga Hills. In 1903-04 he made his first acquaintance with Tibet by accompanying the Tibet Frontier Commission. This country seems to have put a spell upon him which he never lost. He made a study of its language which he maintained for years in Calcutta with the help of a Tibetan *munshi*, in the hope of returning to the land which had so fascinated him. His liking for Tibet and its people seems to have been reciprocated, for I doubt if any other traveller can boast of having won the confidence of these suspicious folk to the same extent as did Hayden. His treatment of coolies and local officials was governed by a most efficient mixture of tactful kindness and manly firmness. It was always a matter of great satisfaction to him that he had left things easy for any traveller coming after him. This idea seems to have taken a very strong hold on him, and to follow in his foot-steps, as the present writer has often done, invariably meant a ready welcome, generous hospitality and loyal assistance.

During 1907-08 his services were lent to the Amir of Afghanistan, and our knowledge of the geology of that country is practically restricted to his memoir and map on the subject and to some papers by Griesbach. In 1913-14 he crossed Chitral into the Pamirs and Central Asia, and made his way into Russia by the Siberian Railway to find that the war had broken out. He reached England *viâ* Scandinavia and at once offered himself for military service. It was one of the greatest disappointments of his life that he was not allowed to join up. On his return to India he flung himself with unsparing and characteristic energy into the development of the wolfram, mica and other mining industries on which the Allies depended.

On retiring from the Geological Survey of India another disappointment met him, for the Government of India refused, on account of his age, to allow him to represent the Geological Survey on the first Mt. Everest Expedition. In 1921 he made a private expedition into Tibet accompanied by an Italian guide, M. Cosson, and returned to Calcutta in the Cold Weather of 1922-23. From a scientific

point of view the results of his investigations proved a little disappointing owing to the disturbed conditions of the rocks. It is hoped to publish shortly the results of these researches which will undoubtedly form a most valuable addition to our scanty knowledge of the Central Asian plateau.

He was the author of some 40 papers and memoirs in the "Records and Memoirs of the Geological Survey of India", and of numerous other contributions in scientific Journals. His best known works are "The Himalaya Mountains and Tibet" in which he collaborated with Sir Sydney Burrard, "The Geology of Tirah and the Bazar Valley" already mentioned, "The Geology of Spiti, with parts of Bashahr and Rupshu," "The Geology of the Provinces of Tsang and Ü in Central Tibet," "Some Coal-fields in North-Eastern Assam," "The Geology of Northern Afghanistan," "Notes on the Geology of Chitral, Gilgit and the Pamirs," and several reviews of the Mineral Production of India. Outside his official duties he took a keen interest in many forms of education and literary activity. He was a past president of the Asiatic Society of Bengal and also of the Mining and Geological Institute of India, and was largely instrumental in setting the Indian Science Congress upon its feet. He was elected a Fellow of the Royal Society in 1915, and was awarded the Bigsby medal by the Geological Society of London the same year. During his Directorship the cadre of the Geological Survey of India was greatly increased.

His death was due to a climbing accident on his return with his two guides from an ascent of the Finsteraarhorn in the Berner Oberland soon after August the 12th, 1923; his body and those of his guides were not found till August the 28th. The accident occurred on the rock arête below the Hugi sattel. Possibly the top of the ridge which is of loose rock may have given way bodily, but the fact that the heels of Cosson's boots were found afterwards to have been torn off points to a gallant but unavailing effort on his part to stop the fall. It is characteristic of Hayden that he insured the life of this guide, who was married, before their expedition together to Tibet.

A man of the most generous impulses, with a contempt for all forms of pettiness and intrigue, he had the peculiarly attractive gift of making friendship with him a bond between his friends. His sense of honour was almost meticulous. In his horror of affec-

tation and pharisaism he frequently endeavoured to conceal one of the kindliest hearts that ever beat beneath an apparent brutality which, however, was so overdone as to deceive none. His attitude towards Science was of that peculiarly English type of simple, childlike self-effacement, combined with a sturdy championship of what he felt was the truth. His characteristic was more that of a healthy perspective than of intensive and brilliant insight, and the solid results he obtained are responsible for a notable and invaluable advance in our knowledge of Himalayan and trans-frontier geology.

Science has lost a devoted and selfless follower whom she can ill spare, and his friends mourn the loss of an attractive and sympathetic personality, a loyal friend and a generous and gallant soul.

THE OIL-SHALES OF EASTERN AMHERST, BURMA, WITH A SKETCH OF THE GEOLOGY OF THE NEIGHBOURHOOD. BY G. DE P. COTTER, SC.D. (DUB.), F.G.S., *Superintendent, Geological Survey of India.* (With Plates 34 and 35.)

PART I—GEOLOGY.

Introduction.

IN November and December 1921, I examined the east of the Amherst district, especially such areas as showed exposures of oil-shales. These oil-shales are the only ones hitherto known in the Indian Empire, and are of Tertiary—probably late Tertiary—age. They occur in synclinal cuvettes or basins resting unconformably upon older rocks. The facies is fresh-water, the shales containing numerous fish remains and dicotyledonous leaves. These basins may be compared with similar Tertiary basins in the Shan States and in Tavoy, which have been mapped by T. D. LaTouche,[1] and Drs. J. Coggin Brown and A. M. Heron[2] respectively, or by members of their parties. But those other basins contain coal-measures or rather lignites, and do not, so far as is known, carry oil-shales.[3] The existence of oil-shales in the Amherst district has been known for several years, but hitherto no account of them has been published. The district itself is one which has been neglected as far as the making of either topographical or geological maps go. Besides a small-scale map (1 inch=8 miles) the only maps of eastern Amherst are Forest maps. These are indeed useful, and are on a sufficiently large scale (4 inches=1 mile) to satisfy the most exacting, but unfortunately they map only Forest Reserves, while cultivated areas remain blank. The map accompanying this paper is reduced from

[1] LaTouche: "Geology of the Northern Shan States." *Mem., Geol. Surv. Ind.*, Vol. XXXIX, (1916).

[2] Brown and Heron: "Geology and Ore Deposits of Tavoy." *Mem., Geol. Surv. Ind.*, Vol. XLIV, pt. 2, (1923).

[3] But Rao Bahadur M. Vinayak Rao has since discovered oil-shale in Mergui district. See *Rec., Geol. Surv. Ind.*, Vol. LIV, pp. 342-343, (1923).

the Forest maps, and contains such additional details as I have been able to add by means of pocket compass and pacing. Towards the close of my tour in Amherst, I was joined by Capt. F W. Walker, who made some valuable additions to our collections of fossil leaves and fishes from the vicinity of Htichara.

The part of the Amherst district herein described lies east of the Dawnas—a range of mountains which, according to the Amherst district gazetteer, rises to a height of 5,500 feet, in latitude 16°5′ North. To the north it extends in a north-north-west alignment, while at the same time decreasing somewhat in altitude. About latitude 17°15′ it is joined by a range of hills known as the Choehko Taung, which spreads to the north into a hilly plateau with rugged limestone peaks. The highest point of this group of hills is the Delaw Taung (2,919 ft. high, lat. 17°2′, long. 98°20′). Another better known peak is the Kamawkala Taung (height 2,239 ft., lat. 17°2′, long. 98°25′).

The Choehko Taung, which runs generally north-east to join the Dawna range, encloses between itself and the Dawna a broad open valley drained by the Mepale river, and it is in this valley, which is a structural one, related to the system of folding of the rocks, that the main Tertiary basin in which oil-shale is found occurs.

This basin lies entirely in British territory while the remaining basins described in this paper lie partly in Burma and partly in Siam. The Mepale river joins the Thaungyin river about 4 miles north-west of the town of Myawaddy; at the junction, rocks of pre-Tertiary (probably Jurassic) age are exposed.

The Thaungyin river, a large stream navigable by rafts from Kyaukket south of Myawaddy to Mitan, but with a few rapids near the Kamawkala gorge, and numerous rapids below Mitan, forms the boundary between Siam and Burma, until it reaches its confluence with the Salween river. Thus the Thaungyin forms the eastern boundary both of Amherst and of Thaton districts. This river shows in various places exposures of oil-shale, and it is clear that there is a basin of Tertiary rocks between Kyaukket and Myawaddy, and again Tertiary rocks north of Myawaddy between this town and the Kamawkala gorge. But it is uncertain whether or not these two basins unite with one another in Siam. No attempt was made to examine any part of Siam, except the actual shores of the Thaungyin river itself.

We may however recognise two basins bisected by the Thaungyin; of these that south of Myawaddy may be referred to as the Phalu basin while that to the north of Myawaddy may be known as the Mesauk-Methalaun-Melamat basin. The third basin, mentioned above as lying entirely in British territory, and in the valley of the Mepale river is that of Htichara, and derives its name from the village of Htichara, near which the main boring operations have been carried out by Messrs. M. E. Moola & Sons, Ltd.

Geological Formations.

According to my interpretation of the geology, the oldest rocks exposed in the east of Amherst district are the banded gneisses and schists and gneissose granites of the Dawna range. The alternative to my view is to suppose these gneisses and granites to be contemporaneous with the granite of Tavoy and Mergui, but the great lithological dissimilarity and the metamorphosed condition of the Dawna gneiss is against such a correlation. The Mergui series, a formation extensively developed in Tavoy and Mergui, is possibly represented by a small outcrop of hornblendic quartz schist seen on the bank of the Mepale, 2½ miles S.W. of Tawokywa. The hills between the Dawna range and the Siamese frontier are composed mainly of two formations, a limestone group, and a red sandstone group which overlies it unconformably. The limestone forms the cores of the main hill ranges, producing rugged and castellated profiles; similar profiles in the distant Siamese ranges across the Thaungyin river show that limestone composes the centre of these ranges also. I have named this limestone the Kamawkala Limestone from the Kamawkala peak (see above) which is one of the best known peaks of this formation. The Kamawkala limestone is doubtfully regarded by me as of Triassic age. Above this limestone, the Red Sandstones rest unconformably. Their great similarity to the Red Sandstones of Kalaw inclines me to the view that, like these they are of Jurassic age. Both the Kamawkala Limestone and the Red Sandstones are highly disturbed, often vertical. With the Red Sandstones is associated a conglomerate, which may possibly be of later age than the main bulk of the Red Sandstones. Above all these formations rests unconformably the Tertiary group, the upper division of which contains oil-shale. The Tertiaries are divisible broadly into two groups:—A, a lower group of sands, boulder beds, and conglomerates, and B, an upper group mainly of shales, and in which oil-shales are developed.

The formations may now be tabulated as follows :—

(1) Dawna Gneisses and Schists	Possibly Archæan.
(Junction with following not seen.)	
(2) Hornblende Quartz Schists near Tawokywa .	Probably Morgui series (Pre-Cambrian).
(Junction with following not seen.)	
(3) Kamawkala Limestone	Lower Mesozoic probably Triassic.
(Unconformity.)	
(4) Red Sandstones	Equivalent to the Kalaw Red Sandstones, probably Jurassic.
(with which is associated)	
(4A) Conglomerates of limestone and red sandstone pebbles	Also found at Kalaw; may be part of Red Sandstone series or later.
(5) Tertiary Beds	
Division A. Sands, conglomerates and Boulder Beds	Probably newer Tertiary.
Division B. Shales with oil-shales interbedded	Ditto.

Dawna gneissose Granites.

In considering the age of the granites and schists of the Dawna Mountains, attention must be paid to the geology of neighbouring countries, such as Siam, Tavoy, and the Shan States. In each of these areas granites and gneisses occur, the age of which has not yet been absolutely settled. In the Shan States Archæan gneisses of an acid type occur near the Katha district, and extend into northern Burma. Biotite-gneisses and biotite granulites are common into which veins of pegmatite, graphic granite and aplite are intruded.[1] They are known as the Mogok Gneiss.

The age of these rocks is unquestionably Archæan. Later granites are found intrusive into the mica schists of Mong Long,[2] these mica schists are regarded by LaTouche as Purana (Algonkian) in age.

The age of these latter intrusive granites is not evident, but it is probable that they may be post-Palæozoic. In 1912 Mr. P. N. Datta[3] found in the Kyaukse district granite intrusive into older rocks, these last being shale, sandstone, and limestone, all rather metamorphosed. Mr. Datta regarded the limestone as Palæozoic, in which case it is probably to be correlated with the Plateau Limestone of LaTouche, which ranges from Devonian to Permian. In LaTouche's map the hills in the north of the Kyaukse district

[1] *Mem., Geol. Surv. Ind.,* Vol. XXXIX, p. 34.
[2] *Ibid,* p. 47.
[3] *Rec., Geol. Surv. Ind.,* Vol. XLIII, p. 29.

are shown as Plateau Limestone, while recent work near Kalaw has shown the presence of Plateau Limestone east of Kalaw. Thus the limestones to the immediate north and to the south-east of Kyaukse are Plateau Limestones. It would appear therefore quite probable that the limestone seen by Mr. Datta in the Kyaukse district is also part of the Plateau Limestone series, and that the granite is therefore post-Palæozoic. If this is the case, perhaps we may regard the intrusive granite of Mong Long as of like age.

We therefore seem to have evidence of two different granites in the Shan States and North Burma, *viz* (1) Archæan granites and gneisses of Mogok, and (2) Intrusive granites of post-Palæozoic age. Turning now to Tavoy, we find that the later intrusive granite is the only granite recognised. It contains, according to Drs. Brown and Heron,[1] veins of tourmaline pegmatite, and itself frequently possesses a pseudo-foliation which, although resembling gneissic structure, is not truly so. It is here intrusive into the Mergui series, which Drs. Brown and Heron regard as Pre-Cambrian.

In the present year (1922) Mr. E. L. G. Clegg examined the head waters of the Yunzalin river in the Salween district. The geological information obtained in this tour gives us some data wherewith to link up the geology of the Shan States with that of Amherst. Mr. Clegg recognises the following formations in descending order :—

(1) Plateau Limestone.
(2) Granite, intruded into (3).
(3) Chaung Magyi Series.
(4) Gneisses with intruded granites and quartz.

Here again two different granitoid series are recognisable, and we may perhaps correlate the earlier granites and gneiss with those of Mogok on the one hand and of the Dawna on the other, while the later granite is perhaps equivalent to the Mong Long granite of the Northern Shan States and to the granite of Tavoy. The Dawna gneiss is a rock quite different to the Tavoy granite. I have shown specimens to Drs. Brown and Heron, who agree with this view. Nowhere in Tavoy is the banded gneiss typical of the Dawna found.

The geology of Siam is known from a description by Mr. Bertil Hogbõm,[2] whose valuable paper sheds much light upon the geo-

[1] *Mem., Geol. Surv. Ind.*, Vol. XLIV, p. 191.

[2] "Contributions to the Geology and Morphology of Siam." *Bull. Geol. Inst. of Univ, of Upsala*, Vol. XII, pp. 65-127.

logy of the Siam-Burma border, and must be taken into account in any description of the geology of Amherst district. Mr. Hogböm (p. 111) considers that "the igneous rocks are of different epochs, as is shown by the fact that there occur quite schistose rocks together with such as do not show any perceptible traces of pressure. Most of them are found in the Pre-Carbonian[1] series, often metamorphosed beyond recognition, but others are met with penetrating the Triassic strata; finally the Tertiary or recent basalts may be mentioned. The granitic rocks ought generally to be considered as relatively young and at least partly penetrating Triassic strata; I have but seldom found gneissic granitic rocks." Near Rahang on the Mei Ping river, about 40 miles east by north of Myawaddy, Mr. Hogböm found granite associated with a limestone which is undoubtedly to be correlated either with the Kamawkala or the Moulmein Limestones. He states that sometimes this granite has the appearance of an eyed gneiss. He adds "The granite in question, as I have mentioned, is obviously entangled in the tectonic movements, but it may be considered as younger than the limestone beds. No evidently intruded veins of it could, however, be observed in the limestones unless possibly further down the river, where it outcrops alternatively with vertically upraised limestone beds. If this is the effect of strong folding or intrusion could, however, not be determined, as no immediate contacts could be found and examined, here or anywhere else along the river. It may be mentioned that granitic rock is not very resistant in the tropics, and thus it is not much exposed."

The weight of evidence is then in favour of recognising two very different granitoid systems, *viz.*

(1) Granitoid gneiss with pegmatites of Archæan age, represented by the Mogok Gneiss of Katha, and the Dawna Gneiss of Amherst;

(2) Post-Palæozoic granites represented by the granite intrusions of Kyaukse district and by the granites of Tavoy and Mergui.

Description of Dawna Granites.

The Dawna Mountains are crossed by the cart-road from Kyundo and Kawkareik to Myawaddy. This cart-road has staging bungalows at convenient intervals. Leaving Kyundo on the Haung-

[1] By the expression "Pre-Carbonian" Mr. Hogböm means *Pre-Carboniferous.*

thraw River, a motor road runs fifteen miles to Kawkareik, the sub-divisional headquarters of the Kawkareik sub-division. The way lies over alluvium, but some whitish clays and grits are visible between milestones 10 and 12, the age of which is not known. Possibly they are Mergui series. Kawkareik is itself on alluvium mainly, but the Forest Bungalow is built on a hill showing exposures of light grey shales and indurated mudstone.

The next stage beyond Kawkareik leads to a bungalow known as Third Camp, which is 23½ miles distant from Kyundo. Near the 20th milestone are exposures of blue shale and mudstone of unknown age—possibly Merguis—but the main deposit is alluvium until the neighbourhood of Third Camp is reached. The first exposure of igneous rock is at the 22nd mile and 5th furlong. Here coarse tourmaline granite pegmatite is seen intrusive into biotite schist.

The granite pegmatite is a pure white rock composed mainly of felspar and quartz with sparse crystals of tourmaline. Flakes of muscovite occur, but are rare, while biotite was not seen. The felspar is seen under the microscope to consist of orthoclase, abundant microcline and in lesser quantity plagioclase having the extinction angles of albite or oligoclase. Quartz is also abundant, both quartz and felspar being allotriomorphic and in fairly large crystals. The biotite schist shows abundant biotite, sometimes bleached, and some muscovite (sericite) probably of secondary origin. Quartz in small grains is fairly common, and grains of plagioclase felspar are less abundant. The intrusive tourmaline granite pegmatite is frequently exposed on the road leading from Third Camp to Thingannyinaung, which last village is not quite 46 miles from Kyundo, and is on the main road to Myawaddy. But the type most characteristic of this section is a schistose biotite-gneiss, usually well banded, made up of crystals of quartz felspar (orthoclase and microcline) and biotite. A specimen from an exposure at the 26th mile and 1st furlong shows a fibrous mineral, probably fibrolite, abundantly present in a rock which may be described as a fibrolite-biotite-quartz gneiss.

Crystals of beryl are said to occur in the pegmatite, but none were seen by me. Sapphires and rubies are reported to occur near Myawaddy[1] but no corundiferous pegmatites were found in the sections through the Dawna gneiss which I visited.

[1] Amherst District Gazetteer, Vol. A (1913), p. 42.

The Mergui Series.

About 2¾ miles south-west of Tawok on the west bank of the Mepale river a well bedded, greenish-grey, hornblendic quartz schist is seen. The dip is steep and to the N. E. No rock of a similar type was seen in any other part of the country visited. It resembles some of the rocks of the Mergui series, and has been provisionally placed in this group.

The Kamawkala Lime-stones.

The Kamawkala Limestones are exposed near the Htichara Forest bungalow about 3 miles north of Htichara, and extend northwards from this point, so as in all probability to join up with the limestones exposed in the Kamawkala gorge of the Thaungyin river, which lies about 15 miles to the north. The limestone is unconformably overlain by the Red Sandstone series, from beneath which it outcrops, both in this main exposure which runs north from Htichara to Kamawkala, and also in several minor inliers in the hills north-east of Htichara and in the Thaungyin river. Similar limestones are found south and west of Phalu, and in the hills south of Thingannyinaung, but they have not been mapped. The hill-ranges in Siam east of the Thaungyin are castellated and obviously limestone, perhaps part of the same series.

The limestone is of a grey colour, hard and crystalline, frequently showing a network of veins of calcite; under the microscope it sometimes shows anoolitic structure of a miniature type. A careful search in the neighbourhood of Htichara Forest Bungalow failed to disclose any trace of fossils, and the weathered surfaces of the limestone showed no trace of any organic structure. This is due partly to the fact that there are no waterworn smooth surfaces in the small streams, but rather a coating of travertine, and a covering of moss and lichen.

But towards the close of my tour I examined the sections exposed in the Thaungyin from Phalu to Kamawkala. On this traverse I encountered several outcrops of limestone with smooth water worn surfaces. In these exposures occasional traces of fossils were discovered from the following localities:—

(1) An exposure of grey limestone on the southern bank of the Thaungyin river, east of Htichara, and S.S.W. of the hill marked Lewa Taung on the Forest map, latitude 16° 47′ 15″, longitude 98° 32′ 3″. Here were found corals both simple and compound, a *Lima*-like shell and fragments of brachiopods.

(2) In the Thaungyin on both sides of the river in a small gorge with limestone on both banks, situated about two miles east of the Kamawkala gorge in latitude 17° 3′ 18″, longitude 98° 26′ 55″.

Here sections of ammonites were found and some rhynconellids.

(3) In the Kamawkala gorge of the Thaungyin in latitude 17° 3′ 20″ and longitude 98° 25′ 15″.

This locality also yielded ammonites and rhynconellids.

The collections from these three localities were sent from Burma to Mr. G. H. Tipper, then Palæontologist to the Geological Survey, for examination, it not being possible, owing to the absence of palæontological literature in Rangoon, to work them out myself. He remarks that the limestones in which the fossils occur are so crystalline that it is impossible to develop the fossils further or to obtain information from their sections. The state of preservation of the ammonites which occur in localities (2) and (3) is poor, but probably all belong to one genus, —an involute form with rather fine continuous ribs. Badly worn sutures are seen on two specimens. Associated with the ammonites are many small acuminate *Rhynchonellae* with well developed ribs and a well marked sinus. From locality (1) there was obtained a badly weathered section of a gastropod with a long spine, unfortunately unidentifiable. There were two ribbed *Pecten*-like lamellibranchs, but the state of preservation was so poor that it was uncertain whether they belonged to *Pecten* or to *Lima*.

Colonial and solitary corals also occur, the former being apparently close to *Latimœandraria* while the latter has not been identified. Mr. Tipper concludes by expressing the opinion that, on the assumption that these fossils come from one horizon as seems likely, it can only be said that they are probably Lower Mesozoic in age, a closer approximation being impossible without better preserved material.

The attribution of a Lower Mesozoic age to these limestones is rather surprising in view of the fact that the limestones of the Shan States, have been proved to be Devonian to Permian,[1] those of Mergui to be Carboniferous,[2] those of the hills north of Moulmein

[1] LaTouche, *op. cit.*
[2] Noetling : *Rec., Geol. Surv. Ind.*, Vol. XXVI, p. 96.

to be also Permo-carboniferous,[1] and the limestones of Siam to be also Permo-carboniferous.[2]

If therefore Mr. Tipper's conjecture is correct it would appear that the Kamawkala limestone is later than the great bulk of the limestones of neighbouring areas. The state of preservation of the fossils is disappointingly poor, and there must remain an element of doubt in the attribution of a Triassic age to these limestones. If however these limestones are really Triassic, it is perhaps possible that they are an upward extension of the Plateau Limestone into the Trias.

The limestone is usually vertical or steeply dipping, generally with a strike to N.N.W., that is parallel with the mountain chains of the area. It is frequently contorted and crushed, although in a less degree than that of the Shan States.

The Red Sandstone Series.

That the Red Sandstone series of East Amherst is as widely spread a formation as the limestone upon which it unconformably rests is evident from the following considerations :—

Purple and red sandstones were observed by Mr. C. S. Middlemiss in the neighbourhood of Kalaw in the Southern Shan States; these beds were associated with sandstones and shales with coal. The lithological appearance of the Kalaw red sandstones is very similar to that of the Amherst red sandstones. Especially a conglomerate made up of pebbles both of red sandstone and of limestone in a matrix of red calcareous fine grained sandstone is found in both areas. The age of the Kalaw red sandstones was vaguely determined by the discovery by myself in January 1922 of fossil plants in the roof of the coal seams near Kalaw. My collection of fossil plants was largely augmented by my colleague Capt. F. W. Walker. I identified the following specimens :—

Cladophlebis denticulata Brong.
Gingkoites digitata Brong.
Pagiophyllum divaricatum (Bunb.).
Brachyphyllum expansum (Sternb.).
Ptilophyllum sp. cf. *P.* non *Otozamites hislopi* (Oldh.).
Podozamites distans (Morris).

[1] Theobald: *Mem., Geol. Surv. Ind.*, Vol. X, p. 326; T. Oldham: "Coal and Tin of Tenasserim." *Rec. of Govt. of India* No. X, page 33; *Rec., Geol. Surv. Ind.*, Vol. LIV, p. 54.
[2] Bertil Hogböm, *op. cit.*

These indicate a Jurassic age, but there are no characteristic Rhaetic or later species, and they might conceivably belong to any part of the Rhaetic or Jurassic.[1]

The Namyau series of the Northern Shan States, described by LaTouche is characterised by its red and purple coloured sandstones and contains a brachiopod fauna of Bathonian age.[2]

Reddish and purple sandstones of unknown age rest unconformably upon Mergui rocks in the islands of Mergui town[3]; it seems not impossible that these are of like age. Red sandstones with conglomerates and shales extend through Siam into Tonkin. At Luang Prabang and in Tonkin Rhaetic fossils have been found, but from some of the lignite beds plants of probable Liassic age have been found.[4]

The Red Sandstones of Amherst, which will be afterwards described in detail, have yielded fragmentary fossils all unhappily unidentifiable and mainly lamellibranchs. Amongst these an *Astarte* not unlike some of the Jurassic species, seems to be most common.

Enough has been said to show the probability that these Red Sandstones are to be correlated broadly with those of the Northern Shan States, Kalaw, and of Siam and Tonkin. May we add also with those of Mergui? There is no fossil evidence for this last correlation which although very possible is at present quite unproved.

Description of the Red Sandstone Series.

As may be seen from the map accompanying this paper, the Tertiary basin of Htichara rests on the west upon Dawna gneiss, and upon the north, south, and east upon either Kamawkala Limestone or upon the Red Sandstone series. This series together with the Kamawkala Limestone occupies all the hilly country east of Htichara. The Red Sandstone hills are easily distinguished at a distance from those of limestone by their rounded contours contrasting with the rugged pinnacles and castellated profiles of the limestone hills. Besides the large mass of limestone north of Htichara Forest Bungalow, which probably extends to Kamawkala, there are several small crags of limestone protruding from the overlying Red Sandstones. Two such crags can be seen about three miles

[1] C. S. Middlemiss in *General Report of the Geological Survey of India for 1899-1900*, p. 143.

[2] *Op. cit.*, p. 303.

[3] *Rec., Geol. Surv. Ind.*, Vol. LIII, p. 26, and Vol. LIV, p. 50.

[4] B. Hogböm, *op. cit.*, pp. 107-108, and Zeiller: "Flore fossile des couches de charbon du Tongking."

N.E. of Htichara, while others occur near the Thaungyin river east of Htichara in latitude 16°47′. The manner in which these curious pinnacles of limestone protrude from beneath the Red Sandstone gives me the impression that the craggy profiles and steep conical hillocks of the former are due in large measure to a pre-Jurassic denudation, which, after having been concealed during the Cretaceous and Tertiary periods by covering deposits of Jurassic Red Sandstone, is again becoming partially revealed in recent times by the continued denudation of this sandstone. This hypothesis may account for some rather puzzling occurrences. In longitude 98° 28′ 3″ and latitude 17° 1′ 30″ north of the junction of the Lehpo chaung with the Thaungyin, the Red Sandstone appears in one section to overlie and in another a few yards to the north to underlie the limestone. This may be easily accounted for by the original rugged and uneven surface of the limestone.

The Red Sandstone series has as its typical and most predominant rock a pink or brick-red to purple sandstone of fine to medium grain, often pebbly. The pebbles are usually small, that is ½ inch to 1 inch diameter and are composed of either pink sandstone or of white quartzite. The pebbles are as a rule sparsely distributed in the sandstone, and are frequently angular to sub-angular.

Associated with the red sandstones are clays of colours varying from grey to cherry-red, conglomerate bands and sandstones of a buff colour. The latter are in appearance very like the much later Tertiary sandstones. The clays sometimes contain thin layers of argillaceous limestone, about 1 to 3 inches thick; these show traces of fossils, mainly lamellibranchs, in the following localities:—

(1) In a tributary of the Hgehka chaung, 3 furlongs S.E. of post 33 of Mepale (Extension I) Forest; longitude 98° 29′ 40″, latitude 16° 46′ 15″.

(2) In the Hatpalu chaung, at two spots, the first 1¼ S.S.W. of Myawaddy, and the second 1½ miles S.W. by S. of Myawaddy, the two localities being not more than a half mile apart. The second locality is about ¼ mile due east of post 24 of the Mekane Forest Reserve.

The fossils from these localities are unfortunately unidentifiable, but amongst them is an *Astarte*, which has been already mentioned.

The red sandstones and clays are frequently steeply dipping or vertical, but have a moderate dip in the neighbourhood of Mya waddy.

Calcareous Conglomerate.

Associated with the red sandstone is found a peculiar conglomerate composed of pebbles or boulders of limestone (Moulmein or Kamawkala Limestone) and pebbles of red sandstone in a matrix of red sandstone. As has been remarked above, an exactly similar conglomerate occurs at Kalaw in the Southern Shan States.

This conglomerate has been found in the following places:—

In the Thaungyin river, there are eight exposures of this conglomerate over a distance (as the crow flies) of six miles, the distance being of course very much longer by water. The most southerly exposure is in latitude 16° 58′ 30″ and longitude 98° 30′ 45″. Here a boulder conglomerate is exposed as a cliff on the north (British) bank of the Thaungyin. In this bed the boulders vary from small pebbles to boulders up to 1 foot in diameter. The boulders are cemented by a matrix of red sandstone, and are of two types, that is grey limestone, obviously derived from the Kamawkala or Moulmein Limestone, and red sandstone. The derivation of the red sandstone boulders is not known. If they are derived from the Red Sandstone group, then the conglomerate would be later in age than the red sandstone. There is however no evidence of such a relationship of the conglomerates to the red sandstones. On the other hand there is no evidence of an earlier red sandstone from whence these pebbles can have been derived. The problem can only be solved by detailed mapping; meanwhile I group these conglomerates with the Red Sandstones, but with the suggestion that they may possibly be of later age or at least a high horizon in the Red Sandstones. From this outcrop the conglomerate bed appears to strike in a direction about 40° west of north. It is again seen in two exposures near the Thekaya chaung, and is of a similar type to that already described. The conglomerates are again seen in the angle of the Thaungyin about 2 miles N.N.W. of the Thekaya chaung. Again, conglomerate is found in the Thaungyin two miles to the N. W. at the mouth of the Mawpathu chaung. To the west of the confluence of the Mawpathu and Thaungyin one sees this conglomerate of Red Sandstone age, while to the east are Tertiary sands with a gentle dip. The red conglomerate dips at angles of about 60°.

Thus it would appear that there is a definite strike of this conglomerate for a distance of about six miles, this strike being parallel to the hill-ranges of the neighbourhood. The conglomerate in the northern exposure is closely associated with Kamawkala Limestone

upon which it is seen in one section near the Lehpo chaung to rest. If however it is a basal bed of the red sandstones we must regard the boulders of red sandstone which it contains as coming from an unknown source. In the present state of our knowledge, it is not possible to state its relationships. but we may provisionally group it with the Red Sandstones. Another locality where a somewhat similar conglomerate was seen is the Pawhkahpu chaung at a point about $1\frac{3}{4}$ miles E.S.E. of Tawokywa. Here a conglomerate of limestone pebbles in a calcareous cement appears vaguely to dip at an angle of about 80° to west. Again in the Thapadaw chaung, not quite $\frac{3}{4}$ mile from the last mentioned spot, is a conglomerate with pebbles of red sandstone. These conglomerates were at the time referred by me to the basal Tertiaries, but it has since appeared to me more probable that they are of Red Sandstone age. But in the neighbourhood of Tawokywa, the geology is greatly obscured by the extraordinarily dense forest. Owing to the difficulties of moving about this part of the country and to the shortness of time at my disposal, I was compelled to leave the study of these conglomerates incomplete.

Tertiary Rocks ; A, Basal Sands.

It has been already remarked that the Tertiary deposits fall into two divisions, a lower group of sands and boulder beds, and an upper of shales with oil-shale. The lower sandy group is extensively developed, and is found in the neighbourhood of Kamawkala gorge in the north, and in the south from Phalu to about four miles south of Phalu on the Thaungyin river. It is found forming a ring all round the Htichara basin, where it extends on both sides of the oil-shales from Tawokywa in the north to Thingannyinaung-ywathit in the south, and it occurs west of Phalu along the Forest Reserve boundary. The sands are generally loose current-bedded sands recalling those of the Irrawaddy series of Upper Burma, but fossil wood although present is very sparsely distributed in them. The wood appears to be in type very similar to that of the Irrawaddy series, and is dicotyledonous. Some large logs were seen on the banks of the Thaungyin at Phalu Forest Bungalow. The sands contain pebbles and boulders of Archæan rocks, *viz.* vein quartz, quartzites, quartz mica schists, tourmaline pegmatites, and granite gneiss. The boulders vary in size from place to place. As a rule they are smaller near the top of the sands, and larger near the base. A diameter of 1 foot is quite common in the basal strata.

But in several spots some enormous boulders were found. About two miles east of Htichara, and a furlong or so S.E. of Forest Post 33 of the Mepale (Extension I) Forest, I saw some boulders of gneiss which were up to 8 feet in diameter. Again about 1 mile N.E. of Tawok-ywa, similar enormous boulders occur. Fairly large boulders are seen also to the west of Phalu in the Tertiary sands exposed along the Mekane Forest Boundary. In places the beds are gravels or loosely consolidated conglomerates, grading into pebbly sands or sands of more homogeneous type.

Near Tawokywa, and in the Mepale river W. and S.W. of Tawokywa, massive beds of coarse arkose and grits of a grey or buff colour are found.

In two localities, not far below the top of the basal sands, reefs of freshwater limestone are developed. The first locality is about 1½ miles E.N.E. of Htichara village. In this locality the limestone is partly silicified. It contains abundant freshwater shells. Collections were made both by Prof. J. W. Gregory in October 1921 and by myself and Mr. F. W Walker about one month later. Both collections were sent to Dr. N. Annandale, Director of the Zoological Survey of India, who is now engaged in the description of the shells. Dr. Annandale has kindly given me a summary of his results. His provisional identifications are as follows :—

Family *Melaniidæ*.
- *Acrostoma intermedium* sp. nov.
- *Acrostoma cotteri* sp. nov.

Family *Viviparidæ*.
- *Vivipara gregoriana* sp. nov.
- *Vivipara dubiosa* sp. nov.

Family *Unionidæ*.
- *Indonaia bonneaudensis* (Eydoux) *see* Fauna of British India Vol. Mollusca (Freshwater Gastropoda and Pelecypoda) by H. B. Preston, p. 140.
- *Indopseudodon rostratus* sp. nov.
- *Lamellidens* (?) *quadratus* sp. nov.

All the species are new with the exception of *Indonaia bonneaudensis*, which is still living. Dr. Annandale considers that the ag of the beds cannot be precisely determined from this fauna but it obviously comes from Tertiary beds and is not very new;

there is nothing against the view that they may be Miocene, but, little in favour of such precision.

The second locality is in latitude 16° 44′ 0″ and longitude 98° 29′ 15″ about half a mile N.N.W. of the hill called Yebu Taung. This hill is one mile west of the confluence of the Mepale and Thaungyin rivers. The limestone here is somewhat silicified, and I saw no traces of fossils.

The basal sand group is easily distinguished from the oil-shale group above by the nature of the forest. The sands are covered by open dipterocarp forest, while a dense growth of bamboos covers the shale country.

The basal sands usually dip at fairly gentle angles. Near Phalu some steep dips were seen (up to 55°) in sandstone, but these were quite local.

Before I conclude my description of the Basal Sands, I may mention that the curiously large boulders of Archæan rock found in some localities near their base are comparable with those boulders of similar large size found by me in the Pleistocene deposits of Pakokku. Like the boulders of the Pakokku district, these of Amherst seem to have been carried several miles from their source.[1]

The basal sands group passes upwards conformably and somewhat gradually into the oil-shale group. The distinction between the two groups is well marked in the Htichara basin. But in the Phalu and the Mesauk-Methalaun-Melamat basin there are frequent sands associated with the upper shale group, while a freshwater shelly limestone is very frequently exposed in the shale group of the latter area. The division of the Tertiaries into two groups is here not so well marked, but still is quite recognisable.

Tertiary Rocks; B, Oil-shale group.

The group now to be described is predominantly clay and shale, but with subordinate beds of sandstone. Thin beds of limestone both of a pure and of an impure type occur, especially in the basin north of Myawaddy, which is bisected by the Thaungyin (the Mesauk-Methalaun-Melamat basin), but they are less common in the other two basins. The limestone contains traces of shells of Melaniids and Viviparids, and is clearly a freshwater deposit. The shales themselves are frequently fossiliferous, and have yielded specimens of teleostean fish, of dicotyledonous leaves, of one fern leaf, and one specimen of a spider. No attempt has been made to identify any of these specimens.

[1] *Journ. Asiat. Soc. Beng.* (New Ser.), Vol. XIV, p. 419, (1918).

Oil-shale is abundant in the lower part of this group, and occurs interbedded with barren shale. It is easily recognisable by its toughness and ability to withstand a sharp blow of the hammer without breaking, by the fact that it can be cut into shavings with a knife while barren shale crumbles to powder, by its dark grey or brown colour, and especially by the peculiar smell given out when a small splinter is heated in the flame of a match. Sometimes the oil-shale is rich enough to ignite when heated. It may occur either in thick layers or in papyraceous laminæ. There appear to be all grades of shale present from completely barren shale to high grade oil-shale. Low grade oil-shale and shales with less than 5 per cent. of volatile matter are abundant, but cannot easily be distinguished from barren shale. No trace of lignites was seen in these beds. All the evidence points to the fact that the group was laid down in fresh water. No trace of salt water fauna has been found. In one section near the base of the shale group, at the bend of the Mepale river opposite post 15 of the Mepale (Extension I) Forest boundary, (that is about 1 mile N.N.W. of the confluence of the Thingannyinaung and Mepale rivers), two thin bands of gypsum, 1 inch and ½ inch thick respectively were seen. This was the only occurrence of gypsum observed.

The country through which the shale group extends is covered with dense jungle, mainly of bamboo. There are few exposures, except in the stream sections. In reserved areas, such as the country between Tawokywa and Htichara, it is impossible to get through the forest without a most laborious process of cutting a path, while the necessity of continually walking in a stooping position is very tiring. The jungle growing upon the oil-shale group of Amherst is probably amongst the thickest found in Burma. In this respect it contrasts with the open forest of rather stunted trees found upon the lower group of basal sands.

Structure of the Tertiary basins.

In the Htichara basin, the dips are usually gentle varying from 20° to 15°. It is rather exceptional to find such a steep dip as that at Pit 1, where the angle is 30°. The dips are not however invariably oriented towards the centre of the synclinal basin, and we must suppose a certain amount of undulation in the strata. The disturbance is of a gentle type. The Phalu basin was not examined in detail, but appears to show very much more minor folding and contortion in the shale zone than is seen at Htichara. The Mesauk-

Methalaun-Melamat basin lies mainly in Siam and only touches upon British territory. The dips are generally gentle and the oil-shales are sometimes almost horizontal.

PART II—ECONOMIC GEOLOGY OF THE OIL-SHALES.

It has already been pointed out that there are three Tertiary basins in Eastern Amherst. These are Htichara, Phalu and Mesauk-Methalaun-Melemat. I visited all three, and collected, a series of samples from each. Those from the latter two basins were unfortunately reported lost in transit between Rangoon and Calcutta but as they were outcrop samples, the results would not have had great significance. From the Htichara basin, on the other hand, I was able to obtain representative samples from pits and drill cores. These were examined by Mr. H. Crookshank in the Geological Survey Office, Calcutta. Preliminary determinations were made of the volatile matter in the dried shales by the same method as is used for the proximate analysis of coal samples. The samples rich in such volatile matter were afterwards subjected to destructive distillation, and in a few instances the ammonia produced was determined at the same time. The apparatus used was designed on the lines of that used by E. L. Lomax and F. G. P. Remfry.[1] 500 grams of shale broken into pieces of smaller diameter than 1 cm. were slowly heated in a horizontal iron retort to 600°C while steam at about 150°C was passed in. The distillate was condensed in a vertical Liebig's condenser leading to a Wolff's bottle. The gases issuing from this were washed with oil to collect heavy hydrocarbon vapours, and with sulphuric acid to collect ammonia. The oil obtained from all the determinations was subjected to fractional distillation, and the results were all scaled down in accordance with the amount of water contained in this combined sample.

Testing the shale samples.

Part of the area under report has been tested with a Calyx drill by Messrs. M. E. Moola & Sons, Ltd., and the cores obtained have been examined by the Company's mining engineer, Mr. R. H. Crozier. He used a vertical electrically heated retort through which steam was passed. The distillate from 500 grams of shale was passed through air-cooled condensers, then through two water scrubbers,

Messrs. Moola's method of testing cores.

[1] *Journ. Inst. Petroleum Tech.*, Vol. VII, 36, (1921).

and through another scrubber charged with a weighed quantity of kerosene oil. Each distillation took about two hours. The water first given off was drained from the condenser and weighed; the results were then calculated on the weight of the shale used, after deducting the weight of this water. The crude oil was drained from the condenser and water scrubbers, separated as far as possible from water and weighed. Mr. Crozier's oil percentages, in my opinion, require a slight correction for water, which can be seen under the microscope in samples of the oil collected. He estimates this at 3 to 4 per cent., but it may be noted that a sample of crude oil sent from Messrs. Moola & Sons to the Geological Survey Office, Calcutta, contained 13 per cent. This, however, Mr. Crozier considers to be far beyond the average. The results of Mr. Crozier's assays, which have been kindly communicated to the Geological Survey of India by Messrs. M. E. Moola & Sons, are given in tabular form at the end of this paper.

Oil contents of the Shale.

We may now consider the nature of the oil-shales in each of the three basins. From a point about 1¼ miles north of Htichara village to one on the Mepale not quite two miles south of the village, there are numerous outcrops of oil-shale which tend to strike in a N.-S. direction. This is the area which has been drilled by Messrs. Moola & Sons. The oil-shale, which outcrops about 1¼ miles north of Htichara camp, is to be seen in the Thelamedaw chaung, and is under water in the bed of the chaung. A sample of the dried shale taken by me was analysed in the Geological Survey Office, and gave 2·59 per cent. of moisture, 49·25 per cent. of volatile matter in the dry sample and 54·41 gallons of oil per ton of shale. Another outcrop, about ¼ mile west of pit 5, showed 42·57 per cent. of volatile matter. Further south, samples were taken from four pits which had been dug by Messrs. Moola & Sons, Ltd. Of these four pits the most northerly is pit 1. This was about 13 feet deep. Three samples were taken from it, *viz.*, sample 1, or the top 2 ft. 5 ins., sample 2, or the next 6 ft. 9 ins., and sample 3, or the next lower 3 ft. 9 ins. Of these samples, sample 1 showed alternate layers of clay and shale, sample 2 was mainly oil-shale, and sample 3 was oil-shale with thin partings of clay, similar to sample 1.

Sample 1 gave 7·44 per cent. of moisture and 23·02 per cent. of volatile matter.
" 2 " 5·55 " " " 29·66 " " " "
" 3 " 8·61 " " " 29·83 " " " "

Sample No. 1 yielded 9·78 gallons of oil and 20·65 lbs. of ammonium sulphate per ton of shale.

Pit 4, about 3 furlongs to the south, is just over 25 feet deep. From this pit 4 samples were taken as follows :—

Sample 4 from a thickness of 6 ft. 4 ins., from a depth of 2 ft. to a depth of 8 ft. 4 ins., contained 4·16 per cent. of moisture and 33·10 per cent. of volatile matter.

Sample 5 from a thickness of 8 ft. 4 ins., from a depth of 8 ft. 4 ins. to a depth of 16 ft. 8 ins., contained 3·63 per cent. of moisture and 30·09 per cent. of volatile matter.

Sample 6 from a thickness of 3 ft. 4 ins., and from a depth of 16 ft. 8 ins. to 20 ft., contained 5·28 per cent. of moisture and 30·41 per cent. of volatile matter.

Sample 7 from a thickness of 5 ft. 1 in., from a depth of 20 ft. to 25 ft. 1 in., contained 4·47 per cent of moisture and 25·09 per cent. of volatile matter.

The richest sample, No. 4, yielded 16·20 gallons of oil and 14·75 lbs. of ammonium sulphate per ton of shale.

Pit 2 lies a furlong or so east of Htichara village. The depth was over 20 ft. Three samples were taken and examined.

Sample 8, from the top 6 ft. 8 ins., contained 5·26 per cent. of moisture and 29·09 per cent. of volatile matter.

Sample 9, from a thickness of 3 ft. 9 ins., next below, contained 2·44 per cent of moisture and 36·10 per cent. volatile matter.

Sample 10, from a thickness of 10 ft. next below, contained 3·41 per cent. of moisture and 32·06 per cent of volatile matter.

The sample richest in volatile matter, No. 9, yielded 14·44 gallons of oil and 16·68 lbs. of ammonium sulphate per ton.

The most southerly pit is pit 3, which is nearly $\frac{3}{4}$ mile south by east of Htichara. From this pit three samples were collected and tested.

Sample 11, from top to 5 ft. 8 ins., depth, contained 5·61 per cent. of moisture and 28·29 per cent. of volatile matter.

Sample 12, 3 ft. 9 ins. thick, from 5 ft. 8 ins. deep to 9 ft. 5 ins., contained 1·76 per cent. of moisture and 36·98 per cent. of volatile matter.

Sample 13, 14 ft. 7 ins. thick, from a depth of 9 ft. 5 ins. to 24 ft., contained 3·5 per cent. of moisture and 29·10 per cent. of volatile matter.

The richest sample, No. 12, yielded 25·01 gallons of oil per ton.

To the south of these pits an outcrop of oil-shale is exposed in the Mepale river just east of the junction with the Htichara stream. This yielded 17·51 gallons of oil per ton and 22·31 lbs. of ammonium sulphate. Volatile matter amounted to 34·05 per cent.

About three miles south of this last locality, there is an outcrop of oil-shale in the Thingannyinaung stream. The rock is entirely under water. A sample of this yielded only 7·94 gallons of oil per ton of shale.

The determinations reported above were made in the Geological Survey laboratory.

Method of Prospecting.

Messrs. M. E. Moola & Sons, Ltd., have drilled the country near Htichara village in the following manner :—

A strip, two miles long from north to south, and one quarter of a mile broad, has been divided into eight blocks of one square quarter mile each. At each corner of these blocks a bore has been put down to about 300 feet or less with a calyx drill. Also a bore has been put down in the centre of each block. The cores thus obtained have been analysed. Three cores were sent to Messrs. Simon Carves, one to the Geological Survey Office, Calcutta, and the rest were analysed by the Company's Mining Engineer, Mr. R. H. Crozier. The positions of the bores are shown on the map given in Plate 34. This map has been kindly supplied by Messrs. Moola & Sons.

Discussion of Mr. Crozier's assays.

From the tabular statements of Mr. Crozier's assays, given at the end of the paper, it will be observed that in bores 14, 15, 16, 17, 18, 20, 21, 22, 23, and 24 there is mention of a mark at certain depths in the midst of rich shale. This mark is a band of calcareous mudstone about 1½ inches thick and is regarded as a datum line whereby to correlate the bores in which it occurs. The persistence of this peculiar stratum throughout the bores, together with the similarity of the shales associated with it, indicates a considerable regularity in the bedding. It is unnecessary in this general description of the oil-shale area of Amherst to enter into minute detail regarding the various richer strata of oil-shale in Htichara. The figures of the analyses given above are easily intelligible to anyone who wishes to study them, and they indicate the presence of several quite rich strata of oil-shale, the richest being that associated with the mark band, the others being at various heights vertically above this mark seam. The seam associated with this mark band is about 6 to 7

feet thick and contains according to Mr. Crozier's analyses between 15 and 19 per cent. of crude oil. Underneath this thickness of six to seven feet of rich shale, the strata are considerably lower grade, but contain some oil. Thus for instance in bore 21, there is a thickness of 8 ft. 7 ins. of shale carrying 9·35 per cent. of crude oil situated 3½ feet below the rich stratum.

Above this seam, the Company have located five other seams, the position of which is shown on the map (Plate 34). These seams have been struck in the various bores listed above, and the depths at which they have been struck by the bores are indicated on the map. Thus the seam immediately above the mark seam (marked f on Plate 34), is struck in bore 23 at 93½ feet, and here we find a total thickness of 5 ft. 8 ins. of rich oil-shale, carrying 13·26 per cent. of crude oil, in 14 ft. 2 ins. of strata.

Above this, in the same bore is a seam 4 ft. 8 ins. thick, carrying 10·93 per cent. of oil. Above this, bore 19 shows three more fairly rich seams, *viz.* from a depth of 207 ft. 2 ins. to 228 ft. 6 ins. a thickness of 11 ft. 5 ins. carrying about 11 per cent. of oil associated with 5 ft. 11 ins. of lower grade shale carrying 4·21 per cent. of oil. Above this at 139 ft. 5 ins. depth there is a thickness of 12 ft. 7 ins. carrying 8·68 per cent. of oil. The highest seam shown in these bores, is low grade; there are 5½ feet of shale carrying 8·02 per cent. of oil associated with considerable thicknesses of lower grade shale. The seams above that marked f are marked a, b, c, and d on the map, seam a being the uppermost.

It is not necessary to go into further detail regarding these seams since a careful perusal of the bore records and the map will give all the information required. Enough has been said to show that *primâ facie* these oil-shales are reasonably rich in certain zones, and their economic possibilities are worthy of serious consideration.

Nature of the oil from the Htichara Oil-shales.

A sample of crude oil, forwarded to the Geological Survey Office, Calcutta, by Messrs. M. E. Moola & Sons was analysed by the Curator with the following result:—

	Per cent.
Water	13
Light naphtha (up to 150°)	4
Heavy „ („ „ 150°-200°)	3
Kerosene, light and heavy to 300°	23
Lubricating oil above 300°	40
Residue above 400°	17

Messrs M. E. Moola & Sons also sent a sample to Messrs. Simon Carves, whose results were as follows :—

	Per cent.
Naphtha from gas	1·36
Light naphtha	4
Light burning oil	13
Heavy burning oil	20[illegible]
Lubricating oil	43
Paraffin wax	16
Coke residue	10

Economic Value of the Oil-Shales.

The above details give what is probably a fairly accurate idea of the east flank of the Htichara basin. It now has to be considered whether these shales could be developed commercially. On the general prospects of the oil-shale industry reference may be made to the recent monographs of H. B. Cronshaw and V. C. Alderson.[1] As these works, as well as various papers in the journals connected with petroleum, discuss the general prospects of the industry, it is not necessary to say much about it here. There is however a general consensus of opinion that owing to the increased consumption of oil and the limited number of oil-fields, many of which are declining, the various deposits of oil-shale will sooner or later have to be worked. The success of the oil-shale industry in general must depend to a great extent upon the maintenance of a good price for oil; a reversion to the low prices prevailing before the war would probably render the development of a shale proposition not greatly profitable. But with a fairly high level of market prices, and reasonably low production costs, there appears no reason why a shale proposition should not pay well. Each field has its own problems and difficulties which have to be encountered and overcome. Much will also depend upon the skill and extent of the operations; a small plant is less likely to pay than one which works large quantities of shale. In the Htichara field, there appears to be a good supply of shale of a rich or fair average quality, so much in fact that it would be possible to obtain large quantities of shale by open-casting. Mining again is fairly simple; the strata dip gently, they appear to be fairly regular, the barren shales can form an excellent roof and floor, while the shales themselves would

[1] H. B. Cronshaw : "Oil Shales," (London, John Murray, 1921) ; V C. Alderson : "The Oil Shale Industry", (F. A. Stokes Co., New York, 1920).

form good hard pillars. Probably retorting can be carried out by utilising the gases from the shale for heating.

Difficulties in the way of developing this area (1) the lack of communications with the sea coast; (2) the heavy rainfall and monsoon floods; (3) labour problems; (4) the various retorting and refining difficulties, some of which are very considerable. which must always be encountered in setting up a new industry in a new area. Some of these obstacles appear to be formidable, but perhaps they can be overcome.

The first difficulty, the absence of a good road or railway to Htichara, might be met by the building of a railway to Myawaddy. This route has I believe been surveyed; it is one of the trade routes to Siam, and a railway would derive some revenue from this trade as well at from the heavy non-floating timber which could be worked from the forests near Myawaddy. The railway need not be entirely dependent upon the oil-shale industry for its profits, although I am not in a position to express any opinion upon the prospects of such a railway. The second difficulty, the heavy rainfall, which occurs from July to October, may inhibit the working of open cut quarries during those months to a considerable extent.

The rainfall at Mepale has been recorded by Messrs. Steel Bros. and Co., Ltd., who have kindly furnished me with returns of rainfall for a period of ten years from 1913 to 1922. According to these statistics the average annual rainfall at Mepale is 81·1 inches that is rather less than half that of Moulmein. Although so much less than that of Moulmein, the rainfall is heavy and falls mainly between May and October. Hence the country is flooded during part of the rains, and the streams are swollen level with or over their banks. Nevertheless something might be done by a system of drainage canals. Mining also could probably be carried on. As regards the remaining difficulties, it seems premature to discuss them. On the whole, the general impression gained from a study of the subject is that the oil-shales of Htichara deserve to be seriously considered as a probable source of oil, and that there may be prospects of their successful development.

West and North Parts of Htichara basin.

The west and north parts of the Htichara basin have not been tested; all that can be done is to mention the natural outcrops of oil-shale. There are four outcrops of oil-shale in the Mepale river between Mepale and Htiwapalaw villages; these are shown on the map.

Further north there is an outcrop of oil-shale just west of Pute village on the bank of the Mepale river. Another outcrop of oil-shale is seen on the bank of the Mepale river about 1¼ miles north by east of Pute. There are also oil-shales about 3½ miles south-east of Tawokywa in the country near the junction of the Bawthalu and Pawhkahpu chaungs, and not quite half a mile east of the junction. These were the only outcrops seen, besides those already described. They indicate the presence of oil-shale all round the Htichara basin, but give us no information of the thickness, richness or extent of the oil-bearing strata. Doubtless all this area will in time be prospected.

The Phalu basin.

It is clear from the map that the greater part of the Phalu basin lies in Siam. Myawaddy itself is on alluvium, but the Jurassic Red Sandstone series outcrops quite close to the town both to the north and south. The first shales are exposed near Maw-taw-tale village about 5 miles south of Myawaddy. Here in the Thaungyin river the oil-shales are well exposed. At the top of the section are three feet of fairly rich looking oil-shale, with some barren or low grade shale below, followed again by a thickness of 9 feet of not very rich looking oil-shale, but containing some rich looking bands.

South of this exposure oil-shales are again seen in the Thaungyin at the 9th mile and 4th furlong on the road to Phalu. Here I saw the following section :—

	Ft.	Ins
Sandy shales	5	0
Oil-shales, fairly rich in appearance	3	0
Oil shale, poor looking	0	6
Sand	0	6
Shale (? oil-bearing)	0	6
Sand	0	6
Clay and shale	5	0
Sandy clay	0	6
Oil-shale	2	6
Sand and shale	2	0
Sandstone	1	0

The two outcrops of oil-shale mentioned above are insufficient to give us any clear idea of the value of the Phalu basin, but if the Htichara basin is developed, it will doubtless be worth while to test this area further.

The Mesauk-Methalaun Melamat basin.

This basin which lies north of Myawaddy, and stretches as far as Kamawkala Gorge, exposes the upper oil-shale division of the Tertiary rocks in several sections east of Htichara along the Thaungyin. The northern section near Kamawkala is in the lower division of Tertiary basal sands. The most southerly exposure of oil-shales in this basin is one on the Siamese bank of the Thaungyin about $1\frac{3}{4}$ miles N. N. W. of Myawaddy. The oil-shales appear to be of a low grade quality here. For six miles to the north the Thaungyin passes through red sandstones, its course lying west of the Tertiary basin. In the latitude of Htichara, the Thaungyin turns east again, and traverses the Tertiary basin. Oil-shales are exposed on the Siamese bank $\frac{3}{4}$ mile south of the Lewa Taung, and again 1 mile east and $1\frac{3}{4}$ miles east of Lewa Taung, and further down stream, they are found $1\frac{3}{4}$ miles east by north of the Hketpulu Taung. Of these four exposures, the first shows oil-shale about 1 foot thick, the second oil-shale about 4 feet thick with 4 feet of barren strata, the fourth exposure shows about 1 foot of oil-shale. Two further exposures of oil-shale occur in the Thaungyin about 1 mile and again 2 miles below the last-mentioned locality. The first exposure shows oil-shales about 1 foot thick, the second, which is on the British bank, shows only about 6 inches of oil-shale. The next exposure of oil-shale is about 6 miles to the north at the junction of the Nvali-a chaung with the Thaungyin. The oil-shale exposed here is about 1 foot thick.

Generally the impression derived from my examination of the Thaungyin section is that the Mesauk-Methalaun-Melamat basin is not so rich in oil-shale as that of Htichara, but the best oil-shale of the basin is exposed near the Hketpulu and Lewa Taungs. One cannot however judge from the casual sections of the Thaungyin. It would appear that most of the basin lies in Siam east of the Thaungyin river. The country between Mesauk and Taung Mesauk is possibly oil-shale territory. Nevertheless, if the Htichara basin ever is developed, attention will doubtless be directed also to those other basins which lie so near, although they are less accessible. We however know little about these basins, and must at present be content with the knowledge that oil-shale does occur in the localities mentioned, and we must refrain from attempting to form any opinion at present of their economic possibilities.

Results of Analyses of Oil-shale from Borings near Htichara by Mr. R. H. Crozier.

Samples in each case have been cut in accordance with the appearance of each individual core and without reference to cores previously sampled :—

BORE NO. 1. Position $\frac{\text{A. 71}}{5\cdot34}$.

Sample No.	Depth.					Sample cut		Remarks.	Percentage of Crude oil.
	Ft.	In.		Ft.	In.	Ft.	In		
1	9	0	to	10	0	1	0	....	11·1
2	12	0	to	16	6	4	6	....	6·16
3	16	6	to	22	6	6	0	....	5·13
4	35	9	to	38	6	2	9	....	12·6
5	38	6	to	43	3	4	9	...	3·52
6	69	0	to	74	0	5	0	....	3·5
7	79	3	to	82	0	2	9	....	8·7
8	92	9	to	98	6	5	9	Not included in average.	2·47
9	115	9	to	117	6	1	9	....	6·28
10	147 143	0 0	to to	150 145	7 0	4	10	...	8·48
11	153	3	to	157	5	4	2	....	5 1
12	167	0	to	170	6	3	6	Hole finished 200 .	6·82

BORE NO. 2. Position $\frac{\text{B. 6}}{3\cdot7}$.

Sample No.	Depth Ft.	In.		Ft.	In.	Sample cut Ft.	In	Remarks.	Percentage of Crude oil.
1	124	6	to	126	6	2	0	....	4·85
2	130	0	to	143	0	3	3	Small bands here.	

BORE NO. 3. Position $\frac{\text{A. 6}}{4\cdot8}$.

Sample No.	Depth Ft.	In.		Ft.	In.	Sample cut Ft.	In	Remarks.	Percentage of Crude oil.
1	2	0	to	10	0	8	0	Excluding 1′ 6″ decomposed shale clay.	11·02
2	10	0	to	14	0	4	0	Not included in average.	2·2
3	14	0	to	20	6	6	6	....	9·08
4	20	6	to	28	6	8	0	....	5·01
5	31	6	to	41	6	10	0	Not included in average.	1·25
6	76	8	to	84	8	8	0		1·80
7	94	0	to	97	6	3	6		5·06
8	106	7	to	113	0	6	5	....	5·06
9	113	0	to	118	7	5	7	....	11·55
10	144	0	to	146	0	2	0	....	5·41

BORE No. 3—*contd.*

Sample No	Depth.					Sample cut.		Remarks.	Percentage of Crude oil.
	Ft.	In.		Ft	In.	Ft.	In.		
11	166	6	to	171	0	4	6	....	3·6
12	185	0	to	186	6	1	6	...	8·8
13	191	6	to	197	0	5	6	....	6 34
14	199	6	to	204	0	4	6	.....	10 52
15	204	0	to	207	0	3	0	..	3·1
16	230	6	to	233	11	3	5	Balance of cores shipped to Simon Carves for analysis.	3·58

BORE No. 4. Position $\frac{A\ 5}{6\ 13}$.

Sample No	Depth.					Sample cut.		Remarks.	Percentage of Crude oil.
1	13	0	to	19	6	6	6		5·12
2	24	0	to	27	0	11	0		10·0
	31	0	to	39	0				
3	19	6	to	24	0	13	6		4·8
	27	0	to	31	0				
	39	0	to	44	0				
4	44	0	to	55	0	11	0	....	3 6
5	55	0	to	57	0	2	0	. .	8 33
6	58	0	to	70	6	12	6	Not included in average	2·2
7	80	6	to	85	6	3	0	.	5 7
8	79	3	to	86	6	4	3	....	3·8
9	90	0	to	94	0	2	0	....	8 13
10	94	0	to	97	0	3	0	.....	4 0
11	103	0	to	104	0	3	3	. ..	4·0
	105	6	to	107	9				
12	120	9	to	124	0	7	3	...	5 45
	128	4	to	132	4				
13	146	0	to	157	3	11	3	....	6 06
14	166	0	to	177	6	11	6	....	3·5
15	185	0	to	189	4	4	4	....	3·66
16	213	3	to	215	0	8	9	....	14·38
	216	6	to	219	6				
	224	6	to	227	0				
	228	3	to	229	9				
17	210	0	to	213	3	11	0	Intermediate lower grade bands of sample 16.	5·13
	215	0	to	216	6				
	219	6	to	224	6				
	227	0	to	228	3				
18	232	0	to	235	6	3	6	....	7·04
19	279	0	to	281	0	2	0	....	4·43
20	294	0	to	296	0	2	0	....	6·61

BORE No. 7. Position $\frac{A.}{4}$.

Sample No.	Depth. Ft. In. to Ft. In.	Sample cut. Ft.	In.	Remarks.	Percentage of Crude oil.
1	24 9 to 34 9	10	0	....	3·66
2	34 9 to 39 7 42 2 to 43 2	5	10	....	3·5
3	44 10 to 48 2	3	4	....	2·97
4	57 4 to 65 0	7	8	....	2·68
5	65 0 to 76 0	11	0	Sample includes 15" small limestone bands which could be excluded in mining.	7·94
6	86 11 to 90 3	3	4	....	3·22
7	95 0 to 102 4	7	4	....	2·13
8	113 0 to 117 4	3	6	....	8·47
9	125 0 to 128 6	3	6	....	5·14
10	153 9 to 159 10	6	1	....	5·45
11	168 0 to 170 4	2	4	....	7·65
12	171 8 to 174 0	2	4	....	5·48
13	175 8 to 177 6 178 0 to 181 11 182 0 to 184 0	7	6	....	5·55
14	194 8 to 202 0	7	4	....	5·01
15	205 0 to 208 6	3	6	....	7·03
16	220 6 to 225 0	4	6	....	3·25
17	225 0 to 231 0	6	0	....	2·55
18	231 6 to 235 0	3	6	....	6·98
19	238 6 to 247 0	8	6	....	6·3
20	256 0 to 261 0	4	6	....	2·75
21	263 0 to 268 0	5	0	Not included in average.	1·71
22	268 0 to 270 6	2	6	....	7·78
23	277 0 to 281 0	4	0	....	5·7

BORE No. 8. Position $\frac{A.}{4{\cdot}5}$.

Sample No.	Depth. Ft. In. to Ft. In.	Sample cut. Ft.	In.	Remarks.	Percentage of Crude oil.
1	27 5 to 28 0 29 6 to 31 0	2	1	....	4·9
2	32 6 to 36 6	4	0	....	3·05
3	40 3 to 45 10	5	7	....	6·0
4	46 7 to 48 9	2	2	Not included in average.	1·19
5	73 6 to 75 0 77 4 to 81 6	5	8	....	2·46
6	81 10 to 85 6	3	8	....	3·49
7	116 6 to 118 0 118 6 to 121 6	4	6	....	3·12
8	126 10 to 129 4	2	6	....	5·14
9	134 2 to 135 4 137 0 to 140 0	4	2	....	3·49

BORE No. 8—*contd.*

Sample No.	Depth.					Sample cut.		Remarks.	Percentage of Crude oil.
	Ft.	In.		Ft.	In.	Ft	In.		
10	155	10	to	158	4	2	6	....	13·6
11	163	4	to	166	10	3	6	....	9·09
12	167	4	to	173	4	6	0	....	4·8
13	180	8	to	185	4	4	8	....	3·3
14	199	4	to	202	8	3	4	Not included in average.	1·48
15	203	4	to	206	0	2	8	....	8·75
16	214	6	to	216	6	2	0	....	4·2

BORE No. 9. Position $\frac{\text{A. 25}}{4\cdot25}$.

1	58	1	to	62	5	4	0	....	3·86
2	78	8	to	80	10	3	2	....	6·29
	81	8	to	82	8				
3	86	0	to	88	6	2	6	6″ Band hard yellow lime-stone.	10·00
4	90	8	to	94	11	4	3	....	5·09

BORE No. 13 (Supplementary to Bore No. 9).

1	9	0	to	15	0	6	0	White mark.	20·4
2	20	4	to	23	9	4	2	....	14·7
	27	0	to	27	9				
3	23	9	to	27	0	3	10	....	5·3
	27	9	to	28	4				
4	46	8	to	50	6	3	10	....	8·92
5	50	6	to	53	8	3	2	....	2·69
6	103	8	to	106	3	3	7	....	6·45
	107	0	to	108	0				
7	113	3	to	115	3	5	3	....	7·15
	116	0	to	119	3				
8	153	10	to	155	10	2	0	....	10·55
9	158	10	to	162	10	4	0	....	3·7
10	189	4	to	196	8	7	4	....	3·6
11	196	10	to	200	0	3	2	....	4·9
12	204	4	to	208	6	4	2	....	3·2
13	216	6	to	218	0	3	0	....	3·7
	219	6	to	221	0				
14	225	7	to	227	1	1	6	....	20·0
15	233	1	to	234	9	1	8	....	8·91
[illegible]	241	1	to	245	4	4	10	....	5·05

BORE No. 10. Position $\frac{A.\ 5}{4}$.

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
	Ft. In. Ft. In.	Ft. In.		
1	34 0 to 35 0	1 10	....	16·17
2	42 4 to 44 5	2 1	....	4·12
3	44 5 to 48 6	4 1	....	7·62
4	48 6 to 52 4	4 10	....	3·45
5	52 4 to 56 0	3 8	....	9·52
6	56 0 to 58 6	2 6	....	3·24
7	79 2 to 81 2	2 0	....	4·39
8	113 3 to 114 3 120 4 to 122 6	3 2	....	4·5
9	114 3 to 119 6	5 3	Two white limestone bands 2″ and 5″ wide.	19·16
10	126 3 to 130 10 131 8 to 133 9	6 8	....	11·19
11	125 9 to 126 3 130 10 to 131 8 133 9 to 135 3	2 10	....	3·76
12	148 9 to 152 0	3 3	....	3·5
13	152 0 to 155 0	3 0	....	9·4
14	155 0 to 158 3	3 3	....	3·14
15	172 6 to 177 6	5 0	Not included in average.	1·6
16	187 0 to 191 1	4 1	....	7·75
17	210 5 to 214 8	4 3	....	5·12
18	222 4 to 224 5 218 3 to 221 9	5 7	....	6·72
19	264 4 to 265 10	1 6	....	15·05
20	269 9 to 272 9	3 0	....	4·9

BORE No. 11. Position $\frac{A.\ 25}{4{\cdot}75}$.

1	19 9 to 21 4	1 7	....	11·31
2	28 0 to 32 0	4 0	....	5·57
3	32 0 to 34 9	2 9	....	3·19
4	34 9 to 39 4	4 7	....	14·96
5	40 4 to 46 4	6 0	....	2·95
6	59 9 to 63 3	3 6	....	4·07
7	78 11 to 82 0	3 1	....	4·57
8	94 7 to 101 3	6 8	Shows 1 + 2″ white limestone bands.	17·35
9	93 0 to 94 7 101 3 to 103 0	3 4	....	3·7

BORE No. 12. Position $\frac{A.0}{4 \cdot 5}$.

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
	Ft. In. Ft. In.	Ft. In.		
1	15 0 to 16 6 17 0 to 22 4	6 10	....	4·56
2	23 8 to 29 0	5 4	....	8·69
3	56 6 to 58 0	1 6	....	8·86
4	60 0 to 61 2	1 2	....	3·03
5	71 4 to 72 6 74 4 to 76 9	3 7	....	5·12
6	92 0 to 93 6	1 6	....	10·46
7	99 8 to 103 0	4 4	....	8·64
8	103 0 to 106 6	3 6	....	3·9
9	106 6 to 110 8	4 2	....	14·66
10	112 2 to 116 0	3 10	....	2·42
11	134 11 to 137 11	3 0	....	5·68
12	155 0 to 156 3	1 3	....	5·46
13	156 3 to 160 0	3 9	....	3·76
14	168 0 to 170 6	2 6	....	5·37
15	170 6 to 177 3	6 9	2″ white band at 175′ 2″.	17·45
16	177 3 to 182 2	4 11	....	3·41
17	182 2 to 185 7 188 9 to 191 0	5 8	2″ white band at 186′ 7″.	12·96
18	185 7 to 188 9 191 0 to 192 3	4 5	....	3·88
19	208 2 to 211 6	3 4	....	10·19
20	211 6 to 216 0	4 6	....	3·21
21	229 8 to 231 3	1 7	....	3·34
22	265 9 to 267 9	2 0	....	2·97
23	268 10 to 273 0	3 2	....	5·14
24	276 0 to 279 10	3 10	....	7·0
25	280 6 to 284 0	3 6	....	4·17
26	285 0 to 289 8	3 8	....	0·7
27	243 0 to 243 6 245 9 to 250 4	5 1	....	5·05

BORE No. 14. Position $\frac{A.\ 25}{4 \cdot 75\ (2)}$.

1	19 7 to 21 1	1 6	....	10·87
2	27 1 to 34 8	7 7	....	5·57
3	34 8 to 39 2	4 6	....	11·33
4	41 0 to 43 2	2 2	Not included in average.	1·63
5	58 8 to 61 2	2 6	....	5·76

BORE NO. 14—*contd.*

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
	Ft. In. Ft. In.	Ft. In.		
6	93 9 to 101 3	7 6	Shows white mark at 99′ 4″.	15·11
7	101 3 to 106 0	4 9	....	2·94
8	106 8 to 109 6	4 3	....	14·0
	112 7 to 114 0			
9	106 0 to 106 8	4 10	....	4·63
	109 6 to 112 7			
	114 0 to 115 1			
10	132 4 to 139 1	6 9	....	6·41
11	130 1 to 132 4	3 3	Not included in average.	1·23
	139 1 to 140 1			
12	152 10 to 158 8	5 10		2·64
13	164 8 to 165 8	6 8		0·7
	167 0 to 172 8			
14	173 8 to 184 8	11 0		1·9
15	185 10 to 190 6	5 4	....	3·0
	194 0 to 194 8			
16	190 6 to 194 0	3 6	....	6·5
17	197 8 to 200 8	3 0	....	9·0
18	201 6 to 206 8	5 2	....	5·7
19	229 6 to 231 3	4 3	...	3·14
	232 9 to 235 3			
20	241 5 to 245 3	3 10	....	6·4
21	247 4 to 251 1	3 9	....	4·6
22	271 5 to 279 0	7 7	..	5·9
23	283 2 to 287 10	4 8	....	4·8
24	288 5 to 290 8	6 8	..	3·0
	291 5 to 295 10			

BORE NO. 15. Position $\frac{A.}{4}$.

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
1	2 4 to 4 0	5 2	10″ Clay band 4 4′-10″. Mark at 6′ 6″.	18·81
	4 10 to 8 4			
2	8 4 to 13 8	5 4	....	2·9
3	13 8 to 17 0	3 4	....	12·9
4	17 0 to 21 1	3 1	....	3·1
5	22 11 to 25 1	2 2	....	10·3
6	101 0 to 102 0	4 10	....	4·6
	102 10 to 106 3			
	106 7 to 107 0			

BORE NO. 16. Position $\frac{A.}{5\cdot5}$.

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
	Ft. In to Ft. In.	Ft. In.		
1	14 11 to 15 8	2 4	....	9·2
	22 4 to 23 11			
2	27 0 to 30 0	3 0	....	13·14
3	81 1 to 87 5	6 4	Mark at 85′ 7½″.	16·94
4	92 4 to 100 2	7 10	....	8·44
5	91 0 to 92 4	3 0	....	2·09
	100 2 to 101 8			
6	116 2 to 120 2	4 0	....	7·48
7	120 2 to 123 9	3 7	....	3·72

BORE NO. 17. Position $\frac{A.\ 25}{5\cdot25}$.

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
1	13 5 to 15 0	5 11	....	5·02
	18 8 to 19 4			
	21 8 to 22 8			
	26 0 to 28 0			
2	34 9 to 35 1	3 8	....	15·72
	37 5 to 38 5			
	41 8 to 44 0			
3	34 4 to 34 9	5 2	....	7·00
	35 1 to 35 7			
	38 5 to 41 8			
	44 0 to 45 0			
4	49 8 to 50 1	4 9	....	12 5
	50 4 to 54 8			
5	47 3 to 49 8	7 0	....	3·7
	50 1 to 50 4			
	54 8 to 59 0			
6	59 0 to 61 9	2 9	....	9·7
7	66 9 to 68 9	2 0	....	4·23
8	95 1 to 99 7	4 6	....	4·0
9	115 5 to 119 10	4 5	....	5·6
10	129 1 to 133 3	4 2	....	4·41
11	133 3 to 139 1	5 10	....	8·44
12	161 4 to 162 11	2 5	....	5·72
	165 7 to 166 5			
13	182 10 to 188 3	5 5	....	4·49
14	205 0 to 206 5	1 5	....	9·61
15	213 4 to 219 0	5 8	....	6·68
16	220 0 to 224 0	4 0	....	14·04
17	243 7 to 247 9	4 2	....	3·31
18	260 7 to 266 7	6 0	Mark at 261′ 5″.	17·01
19	266 7 to 271 7	5 0	....	2·57
20	271 0 to 273 6	2 6	....	13·11

BORE No. 18. Position $\frac{A.\ 25}{5\cdot 75}$.

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
	Ft. In. Ft. In.	Ft. In.		
1	8 7 to 12 3	3 8	....	4·15
2	17 3 to 22 0	4 8	....	3·91
3	22 10 to 26 10	3 0	....	3·63
4	27 5 to 29 6	2 1	....	14·74
5	35 0 to 47 11 48 3 to 49 11	14 7	....	8·0
6	69 1 to 72 11	3 10	....	3·87
7	91 10 to 96 5	4 7	....	5·31
8	105 0 to 109 5 110 2 to 112 0 112 5 to 115 11	9 9	....	6·79
9	133 3 to 134 7 136 10 to 137 10	2 4	....	6·17
10	155 1 to 160 4	5 3	....	4·66
11	173 4 to 174 4 180 4 to 183 4	4 0	....	8·85
12	186 0 to 190 6	4 6	....	18·13
13	190 6 to 195 0	4 6	....	3 38
14	208 0 to 211 7	3 7	....	3·91
15	244 0 to 250 11	6 11	Mark.	15·97

BORE No. 19. Position $\frac{A.\ 5}{6\cdot 5}$.

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
1	11 0 to 16 6	5 6	....	8·02
2	16 6 to 22 10	6 4	....	5·19
3	23 9 to 25 10	2 1	....	5·56
4	25 10 to 35 1	9 3	....	4·44
5	35 1 to 42 4	7 3	....	6·66
6	42 4 to 47 4 48 9 to 51 5	7 8	....	6·44
7	53 7 to 58 4	4 9	....	5·31
8	65 0 to 67 5	2 5	....	8·44
9	70 6 to 75 3	4 9	....	4·97
10	81 9 to 84 9	3 0	....	3·22
11	84 9 to 87 9	3 0	....	5·54
12	95 10 to 97 8	1 10	....	8·05
13	104 8 to 109 2	4 6	....	4·63
14	118 0 to 121 8	3 8	....	5·11
15	124 6 to 129 10	5 4	....	5·08
16	139 5 to 152 0	12 7	....	5·68
17	159 2 to 161 3 165 10 to 166 6	2 9	....	6·40
18	176 2 to 179 6	3 4	....	4·63
19	195 3 to 199 9	4 6	....	3·26

Bore No. 19—*contd.*

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
	Ft. In. Ft. In.	Ft. In.		
20	207 2 to 210 4 211 10 to 215 1	6 5	....	11·11
21	210 4 to 211 10 215 1 to 219 6	5 11	....	4·21
22	219 6 to 222 4 223 10 to 226 0	5 0	....	10·95
23	222 4 to 223 10 226 0 to 228 6	4 0	....	4·39
24	228 6 to 231 6	3 0	....	10·35
25	231 6 to 239 7	8 1	....	3·25
26	320 11 to 324 7	3 8	....	4·63

Bore No. 20. Position $\frac{A.\ 25}{6\cdot25}$.

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
1	2 2 to 2 9 9 11 to 20 1	10 9	....	10·33
2	23 9 to 27 0	3 3	....	3·12
3	59 10 to 62 5	2 7	Not included in average.	2·58
4	73 9 to 76 0	2 3	....	6·15
5	86 0 to 91 11	5 11	....	3·91
6	91 11 to 99 0	7 1	....	7·04
7	115 8 to 117 8	2 0	....	10·25
8	140 0 to 141 6 145 4 to 146 9 149 0 to 151 10	5 9	....	6·86
9	151 10 to 152 10 155 9 to 160 6	5 9	....	12·76
10	160 6 to 169 6 166 0 to 168 0	7 0	....	5·00
11	196 7 to 203 9	7 2	Mark 201′ 10″.	15·04
12	209 5 to 212 2 214 8 to 216 0	4 1	....	12·61
13	195 9 to 196 7 205 9 to 209 5 212 2 to 214 8 216 0 to 217 0	8 0	2′ 8″ core lost. Actual core 5′ 4″.	6·28

Bore No. 21. Position $\frac{A.}{8}$.

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
1	6 7 to 9 0 13 4 to 14 1 19 0 to 20 0	4 2	....	6·07
2	23 4 to 31 2	7 10	....	6·33
3	42 6 to 43 7 53 0 to 55 4	3 5	....	5·09

BORE NO. 21—*contd.*

Sample No.	Depth.					Sample out.		Remarks.	Percentage of Crude oil.
	Ft.	In.		Ft.	In.	Ft.	In.		
4	62	4	to	63	5				
	65	3	to	66	5	3	0	....	4·35
	71	9	to	72	6				
5	79	2	to	79	10				
	81	4	to	82	5				
	84	7	to	86	10				
	92	4	to	94	2	9	1	....	15·87
	94	6	to	96	7				
	100	2	to	101	2				
6	79	10	to	81	4				
	82	5	to	84	7	9	6	....	5·91
	86	10	to	92	4				
	94	2	to	94	6				
7	140	1	to	142	6	7	5	....	6·6
	151	0	to	156	0				
8	156	0	to	161	11	5	11	....	10·91
9	171	3	to	172	1				
	174	6	to	174	9	3	5	....	7·38
	184	9	to	185	9				
	187	5	to	188	9				
10	197	3	to	199	5	2	2	....	6·50
11	201	5	to	207	10	6	5	....	8·43
12	207	10	to	213	9	5	11	....	13·20
13	252	6	to	259	0	6	6	Mark at 254′ 5″.	19·14
14	262	7	to	271	2	8	7	....	9·35
15	251	2	to	252	6	4	11	....	4·40
	269	0	to	252	7				

BORE NO. 22. Position $\frac{A.}{6 \cdot 5}$.

Sample No.	Depth.					Sample out.		Remarks.	Percentage of Crude oil.
1	11	0	to	12	4				
	21	9	to	22	9	6	11	....	10·84
	28	1	to	32	8				
2	48	6	to	50	0	1	6	....	9·59
3	70	0	to	74	9	4	9	....	4·74
4	89	3	to	89	8				
	93	7	to	95	3	5	6	....	13·40
	99	11	to	103	4				
5	89	8	to	93	7	8	0	....	5·29
	95	3	to	99	11				
6	124	9	to	126	3	1	6	....	4·54
7	143	5	to	147	9	3	4	....	4·05
8	159	7	to	167	4	7	9	Mark at 165′ 3″.	16·84
9	173	2	to	181	2	8	0	....	10·77
10	167	4	to	173	2	5	10	....	4·36

BORE No. 23. Position $\frac{A.}{7}$.

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
	Ft. In. Ft. In.	Ft. In.		
1	18 4 to 21 2	2 10	....	6·01
2	21 2 to 25 4	4 2	....	3·41
3	30 2 to 36 10	6 8	....	5·27
4	36 10 to 41 6	4 8	....	10·93
5	51 9 to 57 0	5 3	....	4·88
6	69 4 to 72 7	3 3	....	6·52
7	83 3 to 83 8	5 8	....	13·26
	89 0 to 90 4			
	93 6 to 97 5			
8	87 6 to 89 0	80 9	....	4·56
	90 4 to 93 6			
	97 5 to 101 6			
9	111 4 to 115 7	4 3	....	3·91
10	126 8 to 129 9	4 1	....	4·41
	132 8 to 133 8			
11	140 2 to 146 11	6 9	Mark at 145′.	17·60
12	151 3 to 156 6	5 3	. ..	10·22
13	146 11 to 151 3	7 2	....	3·49
	156 6 to 159 4			

BORE No. 24. Position $\frac{A.}{7·5}$.

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
1	3 10 to 4 7	7 10	....	6·73
	6 7 to 8 10			
	10 5 to 10 10			
	12 7 to 14 0			
	20 2 to 21 8			
	22 11 to 24 5			
2	8 10 to 9 5	5 5	....	15·46
	10 10 to 11 9			
	14 0 to 15 2			
	19 2 to 20 2			
	24 5 to 25 11			
	27 1 to 27 4			
3	58 2 to 60 8	2 6	....	4·69
4	80 3 to 84 5	4 2	....	7·12
5	84 5 to 90 5	6 0	....	10·37
6	99 11 to 103 8	3 9	....	5·97
7	115 10 to 120 5	4 7	....	5·05
8	128 10 to 130 0	5 7	....	10·48
	133 8 to 138 1			
9	140 3 to 144 3	4 0	....	14·25
10	130 0 to 133 8	8 7	Not included in average.	2·79
	138 1 to 140 3			
	144 3 to 147 0			

BORE No. 24—*contd.*

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
	Ft. In. Ft. In.	Ft. In.		
11	158 8 to 162 2	3 6	. . .	3·66
12	187 11 to 194 6	6 7	Mark at 192′ 9″.	18·72
13	200 5 to 202 10 205 1 to 206 7	3 11	....	15·10
14	186 11 to 187 11 194 6 to 200 5 202 10 to 205 1	9 2	....	4 75

BORE No. 25. Position $\frac{\text{A. 25}}{6\cdot75}$.

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
1	12 0 to 12 10 13 8 to 14 11 16 5 to 17 10	3 6	....	10 72
2	10 10 to 12 0 12 10 to 13 8 14 11 to 16 5 17 10 to 23 11	9 7	Core from 15′ 3″ to 15′ 8″ lost.	6 26
3	33 0 to 33 6 34 10 to 36 0 38 0 to 41 2	4 10	....	5·05
4	49 1 to 52 4 55 6 to 56 8	4 5	....	4·33
5	61 9 to 65 8	3 11	....	4·82
6	68 11 to 75 7	6 8	Core from 71′ 10″ to 73′ 4″ lost.	4·17
7	82 9 to 84 6 88 0 to 90 10	4 7	....	16·78
8	81 2 to 82 9 84 6 to 88 0 90 10 to 94 7	8 10	Core from 87′ to 87′ 8″ lost.	5·95
9	94 7 to 100 4 104 6 to 106 11	8 2	....	11·63
10	100 4 to 104 6	4 2	....	4·16

BORE No. 26. Position $\frac{\text{A. 25}}{7\cdot25}$.

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
1	8 2 to 9 6	1 4	....	5·01
2	14 9 to 21 2	6 5	Core 15′ to 17′ lost.	3·77
3	30 10 to 32 10	2 0	Core 31′ 8″-32′ 2″ lost.	6·83
4	37 6 to 39 10	2 4	....	6·91
5	52 6 to 62 11	10 5	Core 53′ 6″-55′ 6″ lost, and 59′ 4″-60′ lost.	8·75

BORE NO. 26—*contd.*

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
	Ft. In. Ft. In.	Ft. In.		
6	69 5 to 71 5 75 5 to 76 10	3 5	....	6·84
7	116 4 to 116 8 118 6 to 119 9 122 1 to 125 4	4 10	....	17·46
8	116 8 to 118 6 116 9 to 122 1	4 2	....	4·18
9	129 2 to 131 3 133 8 to 134 11 138 0 to 139 9	5 1	....	12·68
10	131 3 to 133 8 134 11 to 135 7	3 1	....	7·31
11	125 4 to 129 2 135 7 to 138 0	6 3	....	4·18

BORE NO. 27. Position $\frac{A. 5}{8}$.

Sample No.	Depth.	Sample cut.	Remarks.	Percentage of Crude oil.
1	10 6 to 11 8 13 1 to 13 6 14 11 to 15 4	2 0	....	7·39
2	11 8 to 13 1 13 6 to 14 11	2 10	....	2·09
3	31 1 to 35 10	4 9	....	6·53
4	35 10 to 39 5 43 8 to 45 5	5 4	....	8·83
5	75 0 to 78 0 81 0 to 83 0	5 0	....	3·55
6	91 9 to 98 6	6 9	Missing from 97′ 5″-98′ 1″.	6·65
7	111 7 to 117 4	5 8	....	5·43
8	127 8 to 130 1 133 4 to 136 0	5 1	....	89·2
9	136 0 to 146 2	10 2	Missing 137′ 10″-; 142′ 1″-142′ 6″.	6·46
10	146 2 to 153 2	7 0	....	4·78
11	152 2 to 158 7	5 5	....	7·59
12	158 7 to 170 5	11 10	....	6·16
13	170 5 to 175 7	5 2	....	4·61
14	175 7 to 181 2 186 8 to 189 5	8 4	....	10·59
15	181 2 to 186 8	5 6	....	2·59
16	192 2 to 197 8	5 6	....	5·25
17	204 8 to 208 2	3 6	....	4·17
18	208 2 to 211 2	..	....	

BORE No. 28. Position $\frac{A.\ 25}{7{\cdot}75}$.

Sample No.	Depth.					Sample cut.		Remarks.	Percentage of Crude oil.
	Ft.	In.		Ft.	In.	Ft.	In.		
1	5	7	to	8	2	6	1	....	3·79
	10	0	to	13	6				
2	25	6	to	29	6	4	0	....	2·20
3	33	5	to	35	5	2	0	....	9·21
4	38	0	to	46	9	8	9	Missing 39′ 3″-42′.	3·29
5	56	2	to	64	6	8	4	....	4·12
6	73	3	to	81	0	7	9	....	7·74
7	81	0	to	85	5	4	5	....	5·81
8	91	9	to	94	9	4	9	....	6·66
	98	9	to	100	6				
9	136	10	to	144	4	7	6	....	14·29
10	144	4	to	151	4	10	6	....	5·78
	152	4	to	155	10				
11	151	4	to	152	4	3	3	....	12·98
	155	10	to	158	1				

EXPLANATION OF PLATES.

PLATE 34.—Sites of Borings near Htichara. Scale 8″ = 1 mile.
PLATE 35.—Geological Map of Eastern Amherst. Scale 4″ = 1 mile.

PROVISIONAL LIST OF PALÆOZOIC AND MESOZOIC FOSSILS COLLECTED BY DR. COGGIN BROWN IN YUN-NAN. BY F. R. COWPER REED, SC.D., F.G.S.

A series of papers dealing with the geological results of his explorations in Yun-nan has been published by Dr. Coggin Brown in the *Records* of the Geological Survey of India during the last ten years, and there are references in their pages to the discovery of fossils at many localities.[1] The specimens have been entrusted to me for determination, and a Memoir dealing with them will appear in due course in the *Palæontologia Indica.*[2] Although the manuscript is nearly ready for the press, it is thought that in the meanwhile a provisional list of the fossils providing the palæontological evidence for the occurrence of the various stratigraphical horizons would be useful to other workers in Yun-nan and in neighbouring areas. It is interesting to find in the present collection rich faunas of Lower Carboniferous and Permo-Carboniferous age possessing the same general characters as those already described by Mansuy and others in Eastern Asia. There is also a noticeable occurrence of a Devonian fauna from one locality. Attention should also be drawn to the abundant Upper Triassic fauna of Miao-tsway which exhibits somewhat the same characters as that of the Nucula marls of the Sunda Islands and of the Padang beds of Sumatra. The Namyau beds of Bathonian age, which occur in the Northern Shan States, are also represented in another locality and have yielded a typical series of fossils.

LIST OF FOSSILS.

CAMBRIAN.

Lo-chia-ying, (K12·242).[3]
Redlichia cf. *chinensis* Walcott.

[1] See *Rec., Geol. Surv. Ind.*, Vol. XLIII, pp. 173—205, pp. 327—334, (1913); Vol. XLIV, pp. 385—122, (1914); Vol. XLVII, pp. 205—266, (1916); Vol. LIV, pp. 68—86, 296—323 and 323—340, (1922).

[2] It should be pointed out that Dr. Cowper Reed has already described in detail the Ordovician and Silurian fossils collected by me in Yun nan. See *Pal. Ind.*, new ser., Vol. VI, Mem. No. 3, (1917).— J. Coggin Brown.

[3] These numbers refer to those under which the fossils are registered in the books of the Geological Survey of India.

ORDOVICIAN.

Pupiao, (K17·558).

Caryocrinus sp.

DEVONIAN.

4½ miles from Chin-chiang-kai, Yung-pe route, (K17·534)

Favosites cognata sp. nov.
Pachypora aff. *polygonalis* Mansuy.
Striatopora retardata sp. nov.
Amplexus yunnanensis sp. nov.
Crinoidal remains.
Orthis cf. *bistriata* Tscherr
,, aff. *Gervillei* Defr.
Chonetes plebeia Schnur. var. nov. *plurilineata.*
,, *sarcinulata* Schloth. var nov. *yungpeensis*
Spirifer sp. a.
,, sp. b.
Atrypa desquamata Sow.
Conocardium sp.
Jovellania sp.
Orthoceras sp.
Sphyradoceras ? sp.
Proetus mediospinosus sp. nov.

LOWER CARBONIFEROUS.

Ta-shih-wo, (K11·987-994) and (K12 235)

Nodosaria sp.
Reniera sp.
Syringopora intermixta sp. nov.
Amplexus sp.
Campophyllum cf. *caninoides* Sibly.
Caninia aff. *Nikitini* Stuck.
,, aff. *Lonsdalei* Keys.
Cyathophyllum fraternum sp. nov.
,, *sororium* sp. nov.
Fischerina insolita sp. nov.
,, *solitaria* sp. nov.
Rhodophyllum elusum sp. nov

Histiophyllum occultum sp. nov.
Cyclophyllum sp.
Poteriocrinus sp.
Fenestella aff. *laxa* Phill.
,, sp.
Glauconome aff. *bipinnata* Phill.
Rhombopora cf. *bigemmis* Keys.
Orthis (*Rhipidomella*) *Michelini* Lev.
,, (*Schizophoria*) aff. *resupinata* Mart.
Schellwienella crenistria (Phill.)
Leptæna analoga Phill.
Productus yunnanensis Loczy.
,, ,, var.
,, *cora* D'Orb. var.
,, *longispinus* Sow.
,, *muricatus* Phill. var. nov. *paucispinosa*.
,, (*Pustula*) *impersonatus* sp. nov.
Chonetes cf. *crassistria* McCoy.
,, *papilionacea* (Phill.)
Spirifer bisulcatus (Sow.) var. *trigonalis* Mart.
,, ,, var. *Kleini* Fischer.
,, *duplicicosta* Phill. var.
,, *tornacensis* De Kon.
,, aff. *calcaratus* McCoy.
Spiriferina cristata Schloth. ?
Loxonema sp.
Phillipsia spinifera sp. nov.

Sow-wa-shu, (K11·977-K11·979).
Sponge spicules.
Zaphrentis sp.
Bothrophyllum sp.
Campophyllum sp.
Syringopora sp.
Crinoidal remains.
Fistulipora sp.
Schellwienella crenistria (Phill.)
Orthis (*Schizophoria*) cf. *resupinata* Mart.
Chonetes sp.
Productus yunnanensis Loczy ?

Straparollus ? sp.
Euomphalus ? sp.

Ho-shiu-tang, (K11·983, 984).
Textularia sp.
Bigenerina sp.
Trochammina sp.
Chætetes subradians Mansuy ?
Rhodophyllum ? sp.
Histiophyllum ? sp.
Clisiophyllum sp.

Si-yang road, (K12·240).
Michelinia siyangensis sp. nov.

Si-yang gorge. (K12·241).
Dysodonta Deprati Mansuy.
Parallelodon cf. *obtusus* (Phill.).
Edmondia aff. *Goldfussi* De Kon.

Talu-Wei-sha route, (K17·535).
Syringopora mekongensis sp. nov.
Reticularia indica Waag. var. nov. *yunnanensis*
Leperditia viator sp. nov.
,, *Okeni* Munst. var. nov. *intumescens*
,, *subæqualis* sp. nov.
,, sp.
Bairdia cf. *mucronata* Reuss.

Ta-huang-ti and Man-mu route, (K17·540).
Nodosaria sp.
Cyathophyllum sp.
Aviculopecten (*Pterinopecten*) sp.
Murchisonia sp.

Fang-ma-chang, (K11·996), (K17·569).
Hemitrypa sinensis sp. nov.
Polypora cf. *fastuosa* De Kon.
,, sp.
Rhombopora sp.
Crinoidal remains.

UPPER CARBONIFEROUS.

Tzu-men-lu, (K12·236).
Neoschwagerina craticulifera (Schwager).
Fusulina cf. *montipara* Ehrenb.

Nakoli-Pu-erh-Fu, (K17·548).
Endothyra sp.
Valvulina sp.
Bigenerina sp.
Fusulina sp.
Climacammina ? sp.
Trochammina ? sp.
Neoschwagerina sp.
Geodites sp.

Yang-lin road, (K12·239).
Fusulina sp.
Endothyra sp.
Reniera ? sp.

Tang-chi, (K12·237).
Fusulina sp.
Endothyra sp.
Cribrospira sp.
Reniera sp.
Haplistion ? sp.
Sollasia cf. *Dussaulti* Mansuy.
,, ? sp.
Arœopora ramosa Waag. & Wentz.
Menophyllum ? sp.
Orthis (*Rhipidomella*) aff. *Pecosi* Marcou
Spirifer (*Martinia*) *tangchiensis* sp. nov.
,, (,,) sp.
Athyris (*Spirigerella subtriangularis* sp. nov.
Microdoma ? *parvituberculata* sp. nov.
Naticopsis ? sp.

Eul-kai, (K12·233).
Campophyllum vigilans sp. nov.
Productus ? sp.

Streptorhynchus aff. *pelargonatus* Schloth.
Athyris (*Seminula*) cf. *subtilita* Hall.
,, (,,) *eulkaiensis* Mansuy ?
Spirifer sp.
Euomphalus (*Schizostoma*) cf. *catillus* Mart.
Pleurotomaria (*Mourlonia* ?) *eulkaiensis* sp. nov.
Bellerophon (*Waagenella*) sp.

CARBONIFEROUS, (Lower or Upper).

Yen-tsu-shao, (K12·238).
Indet. foraminifera.
Dibunophyllum ? sp.
Spirifer (*Martiniopsis*) *orientalis* Tschern. var.
Porcellia ? sp.

Between Möng-chu and Ping Chang, (K17·566).
Archimedes ? sp.
Indet. foraminifera.
Crinoidal remains.

East of Yung-chang Fu plain, (K17·570)
Phillipsia (*Proetella* sp. nov.) *cognata* sp. nov.

Wan-chia-tien, (K17·552).
Zaphrentis ? sp.
Campophyllum aff. *Schrenki* Stuck.

Yunnan-i, (K17·554).
Haplistion ? sp.
Amplexus ? sp.
Amphipora aff. *socialis* Roman.

Between La-meng and Tai-ping-tzu, (K17·550).
Lithostrotion ? sp.

Ta-wang-miao, (K17·556).
Endothyra ? sp.

Western side of Pu-piao plain, 2 miles from village, (K17·557).
Indet. coral.
Chonetes ? sp.

Tsin-niu-kai, (K17·540, K17·567).
Geodites ? sp.
Indet. gastropods.

Than-say, (K11·981).
Fenestella sp.
Crinoidal remains.

Ta-huang-ti—Nahsai route, (K17·539).
Indet. foraminifera.

Range to east of Yung-pe valley, Sinchang route, (K17·555)
Amphipora sp.

Pass to Kai-tou, (K12·243).
Chonetes hardrensis Phill. ?

Talu—Wei-sha, (K17·560).
Amphipora asiatica sp. nov.
Heliolus sp.

Tsin-tsun (K12·234).
Alveolites ? *Thomsoni* sp. nov.
Dibunophyllum sp.
Uralinia ? sp.

PERMO-CARBONIFEROUS.

Ta-li-shao, (K12·231).
Michelinia yunnanensis sp. nov.
Syringopora ? sp.
Zaphrentis sp. 1.
,, sp. 2.
,, sp. 3.
Poteriocrinus cf. *maschatensis* Roman.
,, sp.

Crinoid stem, type 1.
,, type 2.
,, type 3.
,, type 4.
Fenestella assumpta sp. nov.
,, *elusa* sp. nov.
,, sp.
Rhombopora ? sp.
Thamnicella orientalis sp. nov.
Acanthoclema ? sp.
Geinitzella sp.
Orthotichia Morgani (Derby).
Derbya cf. *grandis* Waag.
Productus semigratiosus sp. nov.
,, *tenuistriatus* De Vern.
,, cf. *cora* D'Orb.
,, (*Pustula*) *pustulatus* Keys.
,, (,,) *Abichi* Waag.
,, (,,) *Waageni* Rothpl. var.
,, sp.
Strophalosia proxima sp. nov.
Chonetes pseudovariolata Nik. var. nov. *yunnanesis.*
,, *Molengraaffi* Broili.
,, cf. *geinitziana* Waag.
,, aff. *transitionis* Krot.
,, sp.
Athyris (*Cleiothyridina*) *roissyana* Keys.
,, cf. *timorensis* Rothpl.
,, (*Actinoconchus*) sp.
Spirifer fasciger Keys.
,, *Fritschi* Schellw. var. nov. *peregrina.*
,, *rajah* Dav.
,, *Schellwieni* Tschern. var.
,, aff. *carnicus* Schellw.
,, cf. *tastubensis* Tschern.
,, cf. *varuna* Dien.
,, (*Martiniopsis*) *talishaoensis* sp. nov.
,, (,,) cf. *chidruensis* Waag
,, (,,) sp.
Reticularia sublineata sp. nov.

Notothyris ? sp.
Camarophoria aff. *Purdoni* Dav.
Rhynchopora ? *emerita* sp. nov.
Aviculopecten hiemalis Salt. var. nov. *alta.*
,, cf. *Deprati* Mansuy.
,, aff. *Kokscharovi* De Vern.
Palæolima scabrosa sp. nov.
Modiola yunnanensis sp. nov.
Parallelodon [*Macrodon*] cf. *multistriatus* Girty.
,, [,,] cf. *tenuistriatus* Meek.
Conocardium aff. *Rouxi* Mansuy.
,, ? sp.
Pleurotomaria ? sp.
Bellerophon ? sp.

Ta-n-shao, (K12·232).
Productus cf. *Cancrini* De Vern.
,, sp.
Spirifer (*Martinia*) cf. *simensis* Tschern
,, (*Martiniopsis* ?) sp.

Ta-'i-shao, (K17·562).
Productus cf. *plano-hemisphærium* Netsch.
Spirifer (*Martinia*) *bellistriatus* sp. nov.

TRIAS.

Ping-chang and Ta-hi-ti, (K17·542).
Encrinus liliformis Miller.
Near Ping-chang (K17·543, K17·544).
Protrachyceras ladinum Mojs.
,, cf. *Reitzi* (Boeckh).
Cœlostylina (*Gradiella*) cf. *semigradata* Kittl.
Pecten cf. *discites* Schloth.
Posidonia cf. *wengensis* Wissm.

Miao-tsway (K11·963, K11·970).
Pecten Nerei Munst. var.
,, (*Syncyclonema*) *subsecutus* sp. nov.
Lima cf. *Telleri* Bittn.
,, aff. *austriaca* Bittn.

Avicula aff. *arcuata* Munst.
Mysidioptera cf. *incurvostriata* Gumb.
,, *paucicostata* sp. nov.
Gervilleia Krumbecki sp. nov.
,, aff. *planata* Broili.
Cassianella cf. *Verbeeki* Krumb.
,, cf. *gryphœata* Munst.
,, cf. *bidorsata* Munst.
Halobia aff. *tropitum* Kittl.
Myoconcha ? sp.
Cucullœa (*Macrodon*) cf. *impressa* Munst.
Leda [*Nuculana*] *yunnanensis* sp. nov.
,, [,,] *perlonga* Mansuy.
,, [,,] aff. *sulcellata* Munst.
Nucula strigillata Goldf.
,, ,, var. nov. *extensa*.
,, *misolensis* Jaworski.
,, *subœquilatera* Schafh. var. nov. *tsuayensis*.
,, *subobliqua* D'Orb.
Palœoneilo prœacuta Klipst.
Cardita (*Palœocardita*) cf. *buruca* (Boehm.).
,, ,, *globiformis* Boettger, var. nov. *Healeyi*.
,, ,, *Mansuyi* sp. nov.
,, cf. *trapezoidalis* Krumb.
Myophoria Verbeeki (Boettg.) var. nov. *curta*.
,, *Mansuyi* sp. nov.
,, cf. *Volzi* Frech.
,, aff. *fissidentata* Wöhrm.
Myophoricardium cf. *lineatum* Wöhrm ?
Pachycardia rugosa Hauer.
Pomarangina ? cf. *cassiana* Bittn.
Rhœtidia aff. *Zitteli* Bittn.
Athyris [*Spirigera*] ? sp.

Beyond Huang-lo-chai, (K17·547).
Trachyceras (*Sirenites*) sp.
Ptychites ? sp.
Cœlostylina aff. *Heeri* Kittl.
Scurria delicata sp. nov.
Cassianella gryphœata Munst. var. *tenuistria* Munst.

Gervillia præcursor Quenst. var. nov. *protracta.*
Pinna aff. *lima* Boehm.
Gonodon cf. *Mellingi* (Hauer).
Cardita aff. *singularis* Healey.
Cardium sp.

Yunnan-i, (K11·971, K11·973-K11·975).
Halobia yunnanensis sp. nov.
,, *pluriradiata* sp. nov.
Hoferia sp.
Leda [*Nuculana*] sp.
Palæoneilo suborbicularis sp. nov.
Buchites ? sp.

Manmu-Naku route, (K17·537).
Pecten aff. *quotidianus* Healey.
Lima (*Plagiostoma*) cf. *nuda* Parona.
Gervillia cf. *præcursor* Quenst.
,, cf. *shaniorum* Healey.
,, cf. *sancti-galli* Stopp.
,, *nakuensis* sp. nov.
Modiola cf. *frugi* Healey.
,, aff. *raibliana* Bittn.
,, sp.
Anodontophora manmuensis sp. nov.
,, cf. *ovalis* Parona.
Myophoriopsis (*Pseudocorbula*) ? sp.
Myoconcha cf. *gastrochæna* (Dunk).
Pleuromya ? sp.
Cardium ? sp.

Near Ta-shan-shio, (K17·538).
(1) Soft greenish mudstone.
Pecten aff. *subalternans* D'Orb.
Gonodon cf. *Mariani* Tomm.
Anodontophora cf. *griesbachi* Bittn.
Palæoneilo aff. *elliptica* Goldf.
(2) Shaly mudstone.
Daonella cf. *Lommeli* Wissm.

(3) Grey limestone.
Thecosmilia aff. *fenestrata* Reuss.
Alveopora ? sp.
Spiriferina ? sp.

JURASSIC, (BATHONIAN).

Two miles below Liu-wun, on the Lu-chiang—Fang-ma-chang route, (K17·536).

Rhynchonella (*Burmirhynchia*) *adjudicata* sp. nov.
,, ,, *conjurata* sp. nov.
,, ,, *præstans* sp. nov.
,, ,, *tenuiplicata* sp. nov.
,, ,, *luchiangensis* sp. nov.
,, ,, ,, var.
,, (*Cryptorhynchia* ?) sp.
Terebratula (*Holcothyris*) *angusta* Buckm.
,, ,, *flexa* Buckm.
,, ,, *pinguis* Buckm. var. nov. *luchiangensis.*
,, ,, ,, var. nov. *olivæformis.*
,, ,, ,, var nov. *longisulcata.*
Ostrea cf. *acuminata* Sow.
,, (*Exogyra*) cf. *auriformis* Goldf.
,, ,, *subrostrata* sp. nov.
Pecten (*Camptonectes*) cf. *lens.* Sow.
,, cf. *wollastonensis* Lyc.
Lima aff. *cardiiformis* Sow.
Gervillia ? sp.
Cucullæa cf. *cucullata* Goldf.
Hippopodium cf. *rhomboidale* Phil.
Cypricardia sp.
Pholadomya ? sp.

JURASSIC, (HORIZON DOUBTFUL).

Bottom of ascent to Tai-ping-tzu, (K17·553).
Pecten aff. *annulatus* Sow.
Exogyra sp.

Waldheimia ? sp.
Rhynchonella ? sp.

JURASSIC OR TRIASSIC.

Between Ta-hi-ti and Man-mu, (K17·568).
Thecosmilia ? sp.
Phyllocœnia ? sp.

OF DOUBTFUL STRATIGRAPHICAL REFERENCE.

(Fossils indeterminable).
(*a*) Ta-huang-ti—Man-mu, (K17·541).
(*b*) 300 feet above the Salween between La-meng, and Tai-ping-tzu, (K17·559).
(*c*) 12½ miles from Shun-kia-tsun, Chi-ta-na route, (K17·559).
(*d*) Above Ping-chang (K17·546).

NOTE ON THE FALL OF THREE METEORIC IRONS IN RAJPUTANA ON THE 20TH MAY 1921. BY L. LEIGH FERMOR, O.B.E., D.SC., A.R.S.M., F.A.S.B., F.G.S. *Superintendent, Geological Survey of India.* (With Plates 36 to 38.)

I—GENERAL REMARKS.

IN the year 1907 I published a paper entitled 'Notes on some Indian Aerolites' [1], containing accounts of the circumstances attendant upon the fall, and of the external characteristics of specimens, of four Indian aerolites, followed by notes on five other falls. A list of meteoritic falls recorded in India up to 1905 is given. The total was 71, of which all but three (Nedagolla, Kodaikanal, and Lodhran) were stony meteorites or aerolites; and of these 71 all except Goalpara and Kodaikanal were seen to fall. It was suggested that during the twentieth century at least one fall a year within the limits of the Indian Empire would be reorded.

Since 1905, *i.e.*, in 16 years, 22 fresh falls have been recorded, so that the expected average has been realised. In addition an earlier fall (Kamsagar) has been recorded, so that the total of Indian falls including two earlier finds (Assam and Singhur) now stands at 96, of which three are irons, —— for one of the latest falls (Samelia, 1921) is a siderite —— and two are siderolites (including Singhur).

For the sake of convenience these 25 falls are listed below in chronological order :—

Date of fall.	Name of fall.	Described.
1846 (found) . . .	Assam	W. von Haidinger See G. T. Prior, Catalogue, p. 9, (1923).
1847 (found) . . .	Singhur	H. Girand see prior *i.e.*, p. 166.
1902, Nov. 12 . . .	Kamsagar	J. Coggin Brown, *Rec.*, XLV, pp. 223-225.
1906, Dec. 15 . . .	Vishnupur	G. de P. Cotter, *Rec.*, XLII, pp. 265-277.
1907, May 9 . . .	Chainpur	
1910, Jan. 7 . . .	Mirzapur	
1910, Sep. 15 . . .	Baroti	
1910, Sep. 19 . . .	Khohar	
1910, Nov. 24 . . .	Lakangaon	

[1] *Rec., Geol. Surv. Ind.*, XXXV, pp. 79-95, (1907).

Date of fall.	Name of fall.	Described.
1911, Jan. 22	Tonk (Chhabra.)	W.A.K. Christie, *Rec.*, XLIV, pp. 41-51.
1912, April	Shupiyan	J. Coggin Brown, *Rec.*, XLV, pp. 221-223.
1913, Jan. 12 . . .	Banswal	J. Coggin Brown, *Rec.*, XLIII. pp. 237-248.
1914, April 6 . . .	Kuttipuram	J. Coggin Brown, *Rec.*, XIV, pp. 209-221.
1915, Jan. 19 . . .	Visooni	H. Walker, *Rec.*, XLVII, pp. 273-279.
1916, April 5 . . .	Ekh Khera	
1916, July 10 . . .	Sultanpur	H. Walker, *Rec.*, LIV, pp. 133-142.
1916 Nov. 21 . . .	Rampurhat	
1917, Feb. 20 . . .	Ranchapar	
1917, July 23 . . .	Cranganore	
1919, May 1 . . .	Adhikot	
1920, Aug. 30 . . .	Merua	
1920, Dec. 23 . . .	Atarra	
1921, Jan. 17 . . .	Haripura	
1921, May 20 . . .	Samelia	
1921, Sept. 9 . . .	Shikarpur	

Accounts of the first 17 falls have been given by Drs. Coggin Brown, Christie, and Cotter, and Mr. H. Walker, in the volumes of the *Records of the Geological Survey of India* indicated ; the remaining 6 are still undescribed, but the falls have been recorded in the General Reports of the Geological Survey of India for the years 1919, 1921, and 1922, respectively.[2]

It is proposed in the present paper to place on record as before the circumstances accompanying the fall of the most remarkable of these new acquisitions, namely the three siderites of the Samelia fall, together with an account of the characteristics thereof.

II—THE SAMELIA METEORITE.

Although over three hundred siderites or meteoric irons and siderolites are now known to science, very few of these have been seen to fall, the remainder having been found lying on the surface, or discovered by ploughing, quarrying, road building and gold washing operations, etc., at depths up to 32 feet from the surface.

[2] H. H. Hayden, *Rec., Geol. Surv. Ind.*, LI, p. 7, (1920).
L. L. Fermor, *Op. cit.*, LIV, p. 10, (1922).
E. H. Pascoe, *Op. cit.*, LV, p. 9, (1923).

The number of siderites and siderolites of which the fall has been recorded, as given in Dr. G. T. Prior's catalogue of meteorites published by the British Museum in 1923, is 23 siderites, and 6 siderolites, of which one siderite (Nedagolla) and one siderolite (Lodhran) are Indian.

Great interest attaches, therefore, to the fall of three meteoric irons in Rajputana on the 20th May 1921. Two of these siderites fell in the jungles of Samelia (25°40′, 74°52′) and Beshki (25°39′ 74°53′) about 7 miles W. N. W. of Shahpura, in the Chiefship of the same name, and the third in the village of Beskalai (74°47′. 25°39′) in the Banera Estate of Mewar, lying immediately to the west of the Shahpura Chiefship. Through the kind offices of the Political Agent, Haraoti and Tonk, and of the Resident in Mewar, and the generosity of the Kamdar of Shahpura, and of the Raja Sahib Bahadur of Banera, these meteorites are now in the collection of the Geological Survey of India. The principal account of the circumstances of this fall is given in a letter from the Kamdar of Shahpura and the Political Agent, Haraoti and Tonk, by whom the fall was first brought to our notice. This account states :—

" On the afternoon of the 20th May 1921, at about 5-30 P.M. a meteor, like a radiant globe, appeared in the sky running from south to north and leaving a white trail in the sky but it disappeared after a quarter of an hour.. The globe burst at last thundering like a volley of guns when several pieces like melted iron are said to have dropped down on the earth. Two of these pieces fell in the Shahpura Chiefship one weighing one seer 2½ chattaks. The other weighing 10½ chattaks."

The account given of the fall in Banera territory states :—

" It fell from the sky accompanied by a loud report produced by the clashing of clouds. It looked like a red hot piece. As it fell it entered the ground to the depth of seven inches ".

The weights of the three meteoric irons are as follows :—

170.A Samelia 1125·36 grammes.
170.B Beshkalai 749·51 grammes.
170.C Beshki 586·88 grammes.

The specific gravities of these three irons have been found to be 7·831, 7·858, and 7·826, respectively.

According to the 1 inch sheet No. 38 of the Rajputana Topographical Survey, Beshki is about 1¼ miles S.S.E. of Samelia; Beshkalai is not marked on this map, but judging from the coordinates as given

in a letter from the Mahakma Khas, Udaipur, to the Resident in Mewar, this village must be close to the village of Dantal and some 5 miles west of Beshki. The distribution of the siderites does not throw much light on the direction of flight, but it is worth noticing that the heaviest piece was found at the most northerly locality, as would be expected if the flight were from south to north as stated.

Brief descriptions of each specimen may now be given.

170. A. Found at Samelia.

This siderite is of irregular angular shape, which will be realised better from the photographs (Plate 36) than from any description. It shows several straightish edges and one triangular face, which presumably bear some relation to the internal crystallographic structure. Except along some of the edges, where the bright metal is exposed, the siderite is almost completely covered with a thin black crust, generally smooth as seen with the naked eye, but showing under the lens a net-work of fine raised lines, which often lie roughly at right angles to the edges, as if caused by the rush of air over these edges acting on the thin molten crust. In places where the flow ridges are fewer or absent the crust is stippled with minute raised points. At one or two corners the metal has been slightly hammered, presumably out of curiosity by the finder. There are a few minute cracks in the meteorite and occasional depressions that tend to be holes and suggest that the siderite when sliced may prove to contain a small proportion of some substance additional to the nickel-iron of which it otherwise appears to be composed.

170. B. From Beshkalai.

This is the specimen found (at Beshkalai) in the Banera estate. Its very irregular shape is shown in the photographs (Plate 37). The irregular surface is again no doubt an index to the internal structure and several of the depressions approximate to the triangular. The crust is very similar to that of 170.A and shows under the lens the same flow lines and stippled points. There are also a few minute cracks, and at certain corners the iron has been slightly hammered. One corner appears to have been broken off subsequent to the formation of the main crust, but prior to arrival at the earth's surface: for the fractured surface reveals a parallel laminated structure in the metal, with the edges of the laminæ slightly fused over.

170. C. From Beshki.

This siderite is much less perfect than the the two preceding. One edge is very crude and appears to have been broken during flight subsequent to the formation

of the main crust, and, as in 170.B, to have been partially fused over, though not sufficiently so to hide completely the laminated structure of the metal. One end of this edge has been severely damaged artificially by filing or hammering. Near the other end of this edge is a right-angled depression showing the basset edges of the laminæ of the metal dipping at about 60° to the edge between the two faces of the right angle. The crust itself is, on one side of the meteorite, considerably thicker than on 170.A and 170.B, and the fusion lines on this portion of the crust are much coarser than on the other siderites and are easily visible to the naked eye. The remainder of the crust is smoother, but with "thumb marks", indicating the direction of the flight; this portion of the crust is thinner than the portion of the crust referred to above, and may be of later age. (Plate 38.)

Although there is no reason for doubting that these three meteoric irons form one fall yet an inspection of the photographs will show at once that there are differences in general aspect. Thus the angularity of 170.A is on a much larger scale than that of 170.B, whilst 170.C is more rounded and less angular than either, with an approximation in appearance towards the "thumb-marked" aspect of some stony meteorites and with the flow lines over a portion of the crust on a much coarser scale than in 170.A and 170.B. A consideration of these facts, with the meteorites before one, drives one to the conclusion that the parent mass was, at the time of entry into the earth's atmosphere, of some magnitude, and that the metal was more coarsely crystallised (170.A) in one part than in another (170.B). The rounding of 170.C and its much thicker crust on one side than elsewhere and than in 170.A and 170.B, and its more evident signs of fusion in the thicker crust, suggest that this siderite was derived from the outer portion of the parent siderite. Similarly the facts that 170.A and 170.B have a much thinner crust and are more angular than 170.C indicate probably that the former were derived from the interior of the parent siderite at the time of disruption and that fracture followed, as might be expected, the lines of crystallographic cleavage; and also that the duration of the flight through the earth's atmosphere subsequent to disruption was insufficient to permit of the same degree of rounding of edges and angles by fusion as characterised the surface of the parent siderite before disruption.

As these three meteoric irons have not yet been sliced, it is not possible at present to give an account of their chemical composition

and internal structure. Indeed, it is perhaps doubtful whether it is in the interest of science to cut up any of these specimens, carrying on their surface, as they appear to do, clues to their recent adven-res.

This siderite is, as already noted, the twenty-fourth of which the fall has been observed. Omitting the two aerolites, Assam and Goalpara, the siderolite Singhur and the siderite Kodaikanal, the fall of which was not observed, we have now records of the fall in India between 1798 and 1921 of 89 aerolites, 2 siderites and 1 siderolite. This is not a very dissimilar proportion from that for the world as a whole as deducible from Dr. Prior's catalogue of meteorites up to 1922, namely 417, 24 and 6.[1] The small proportion of siderites and siderolites to aerolites doubtless has some simple explanation that will one day be forthcoming.[2]

But accepting it as a fact we must regard the 302 siderites recorded in Dr. Prior's catalogue as found up to 1922 as the accumulated falls of a thousand years or more. The siderolites being composed partly of stony materials, have not been so easily preserved and the 30 specimens recorded in Dr. Prior's catalogue as found up to 1922 represent probably an accumulation of a few centuries only.

[1] Including the meteorites listed in the present paper.

[2] Whether we suppose that meteorites are fragments of the earth torn off at the time of departure of the moon, or fragments loosed from the parent body of the solar system at the time of its tidal disruption by near approach of another stellar body [See my paper "Preliminary note on the Origin of Meteorites," *Journ. A. S. B., N. S.*, Vol. VIII, p. 322, (1922)] it seems reasonable to anticipate that a higher proportion of the fragments of the stony crust of the primordial body than of the metallic interior would be flung off into space.

EXPLANATION OF PLATES.

PLATE 36.—Iron meteorite found at Samelia.
PLATE 37.— ,, ,, ,, ,, Beshkalai.
PLATE 38.— ,, ,, ,, ,, Beshki.

MISCELLANEOUS NOTE.

On a Crystal of Monazite from Simultala.

The monazite crystal described below was presented to the Presidency College, Geology Department by Mr. A. T. Bose, M.Sc., who picked it up as a stray specimen, (not *in situ*), near Simultala.

It is a portion of a single crystal and measures $2.8 \times 2.1 \times 1.1$ c.m. The colour is reddish-brown, inclining to black in places. The lustre is resinous but pearly on cleavage faces. Sp. Gr.=5·22. In thin sections the colour is yellow. The crystal shows absorption lines of didymium earths with a direct-vision spectroscope.

The faces of the crystal are so dull that the angles could not be measured with a reflection goniometer. A contact goniometer was therefore used. The following forms are developed — a (100), m (110), w (101), x ($\bar{1}01$), c (001) and v (111). The rare form c (001) is conspicuously developed here, and the crystal has an extremely perfect cleavage parallel to this face.

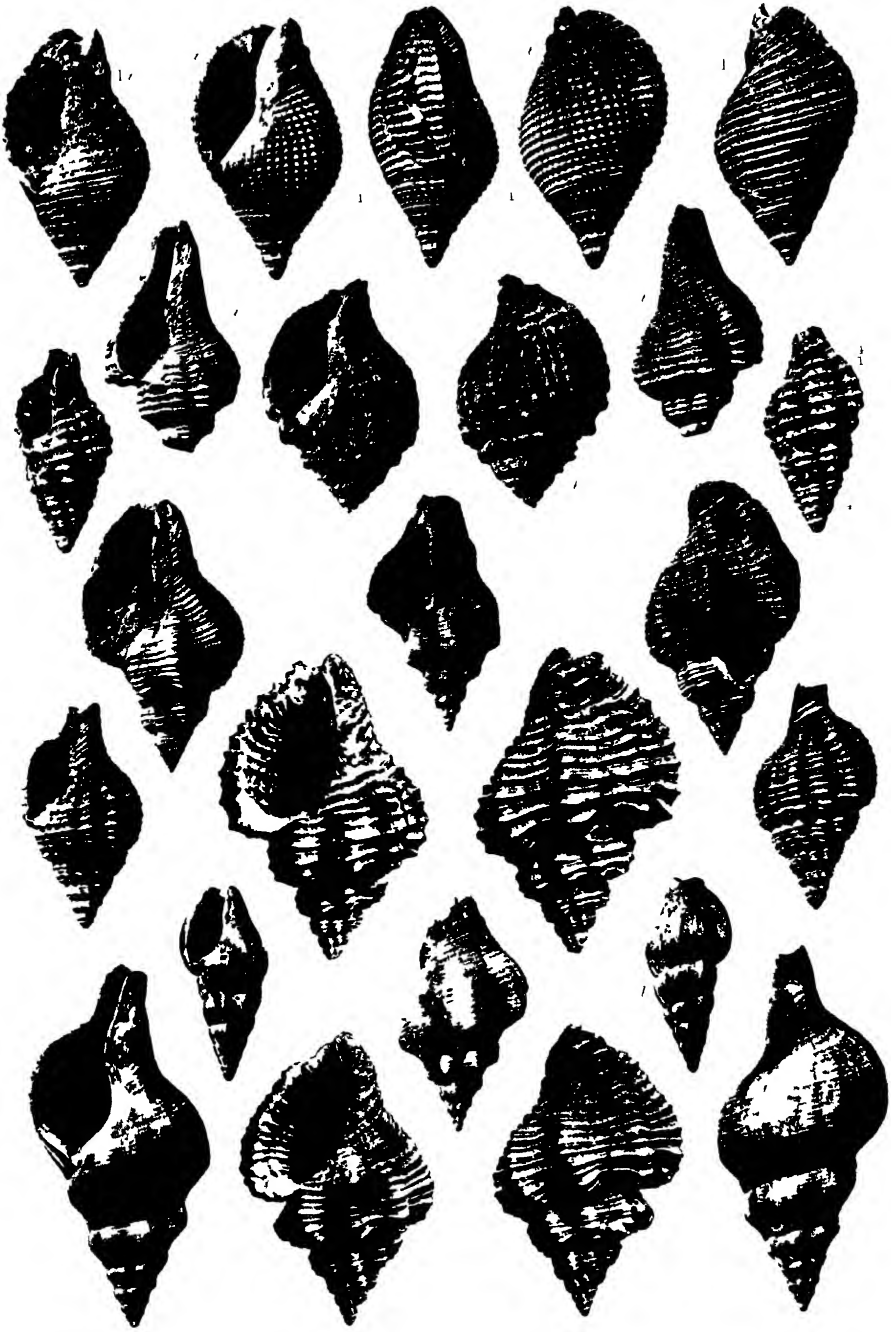
In colour, lustre and specific gravity it resembles the Pichhli (Gaya) crystals described by G. H. Tipper.[1] The crystal is, however, tabular, parallel to a (100), which in this case is the dominant form.

SARATLAL BISWAS.
BHUPENDRANATH MAITRA.

[1] *Rec., Geol. Surv. Ind.*, Vol. L. (1919), p. 259 *et seq.*

INDEX TO RECORDS, VOLUME LV.

CALCUTTA : PRINTED BY SUPDT. GOVT. PRINTING, INDIA, 8, HASTINGS STREET.



1 *a*

2

1 *b*

3 *a*

3 *b*

4 × $\frac{3}{2}$

5 × $\frac{3}{2}$

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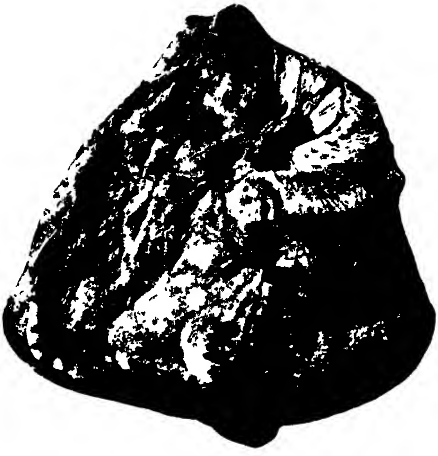
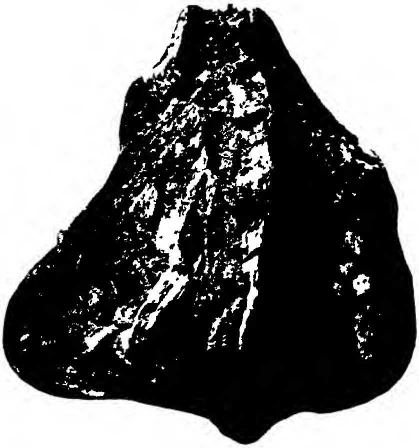
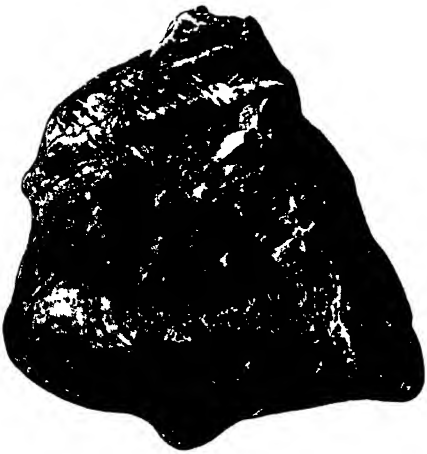
TERTIARY MOLLUSCA FROM BURMA AND SIND.



a



c

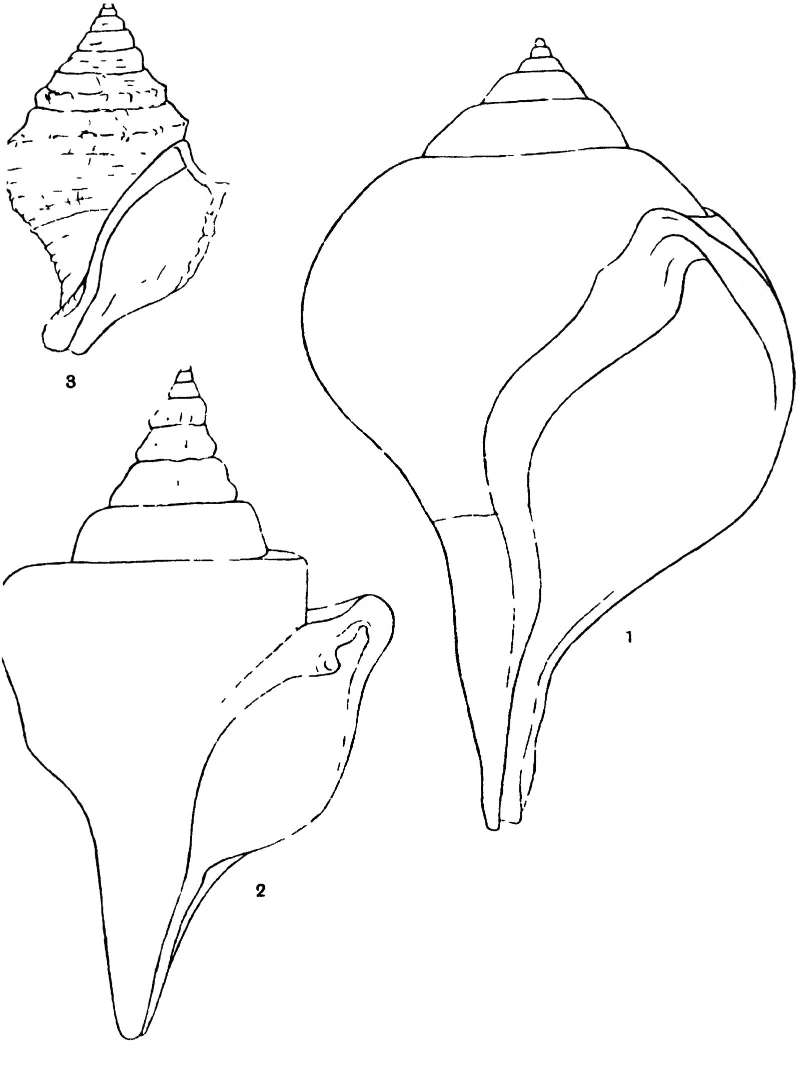


b

d

S. C. Mondal, Photos. *G. S. I. Calcutta*

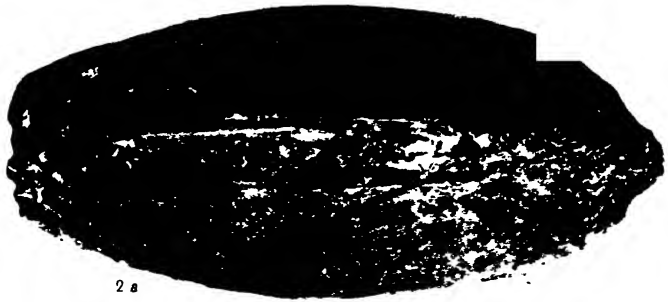
TERTIARY MOLLUSCA FROM BURMA AND SIND.



G. S. I. Calcutta.

RESTORED OUTLINES OF TERTIARY MOLLUSCA FROM BURMA AND SIND.

1 a



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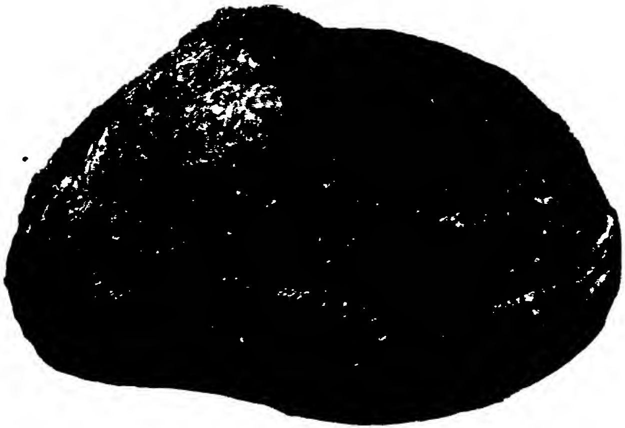

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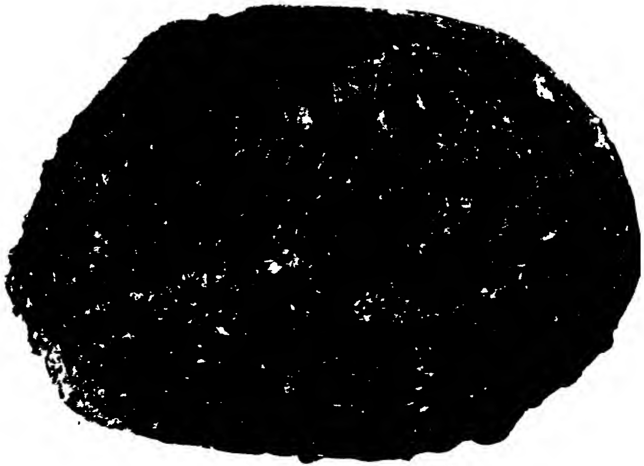
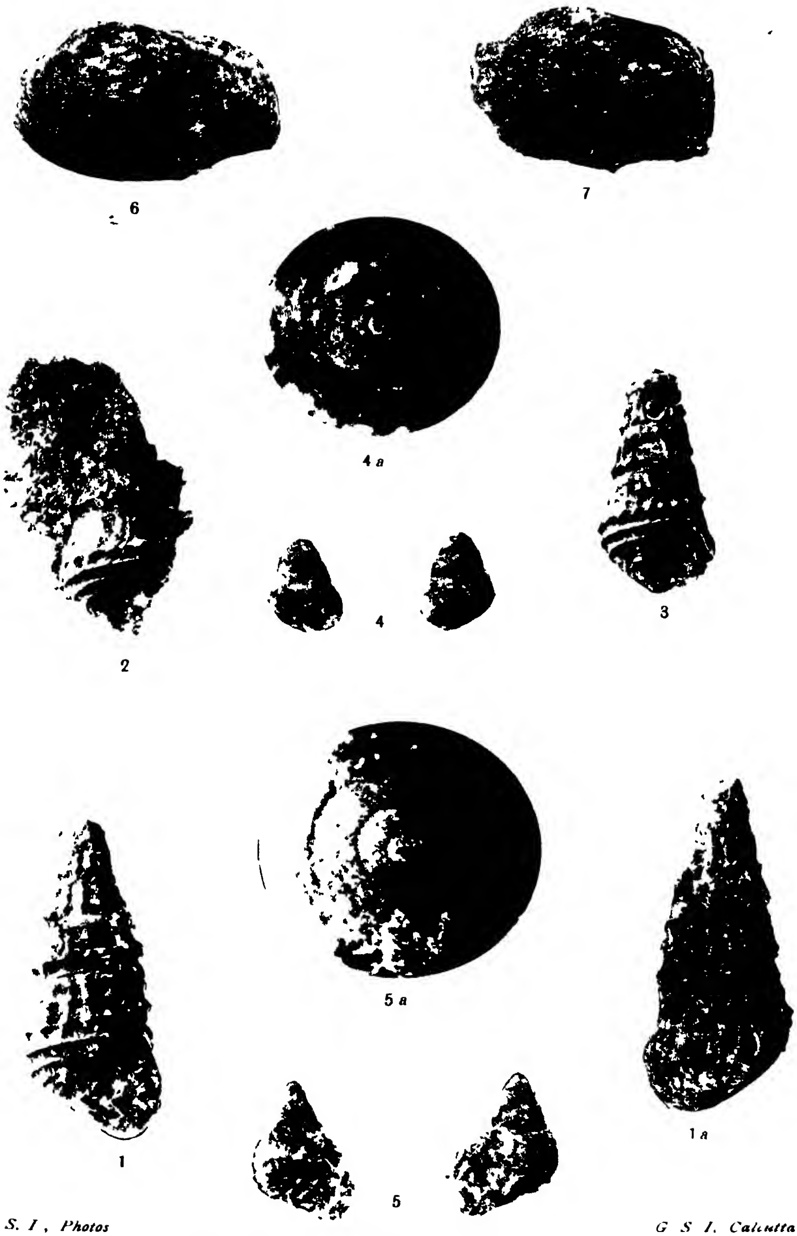


2

Z. S. I. Photos.

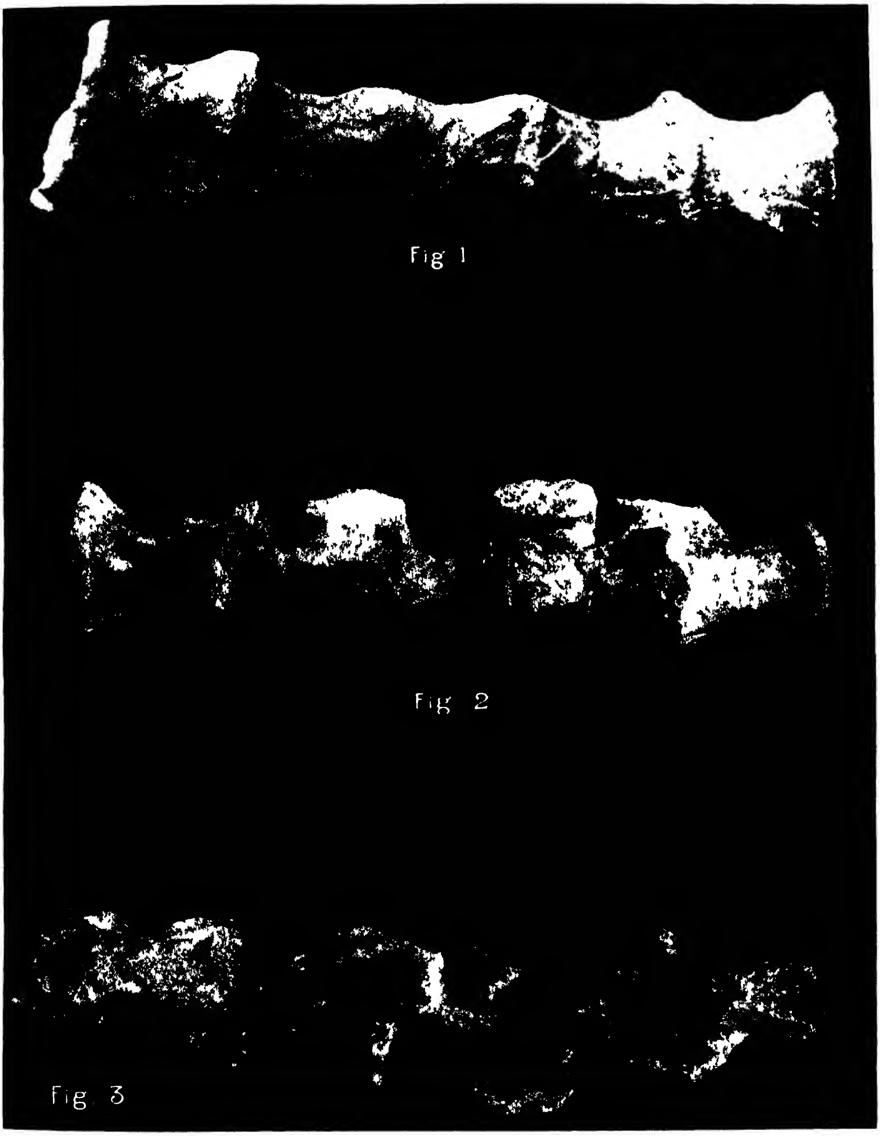
G. S. I. Calcutta

FOSSIL UNIONIDÆ FROM THE DAWNA HILLS.



Z S. I, Photos *G S I. Calcutta*

FOSSIL MOLLUSCS FROM THE DAWNA HILLS.



G S I. Calcutta

Figs. 1, 2 & 3. SACRUM OF LAMETASAURUS INDICUS *(GEN. ET SP. NOV.)*

(Scale about ¼ natural size)

G. S. I. Calcutta

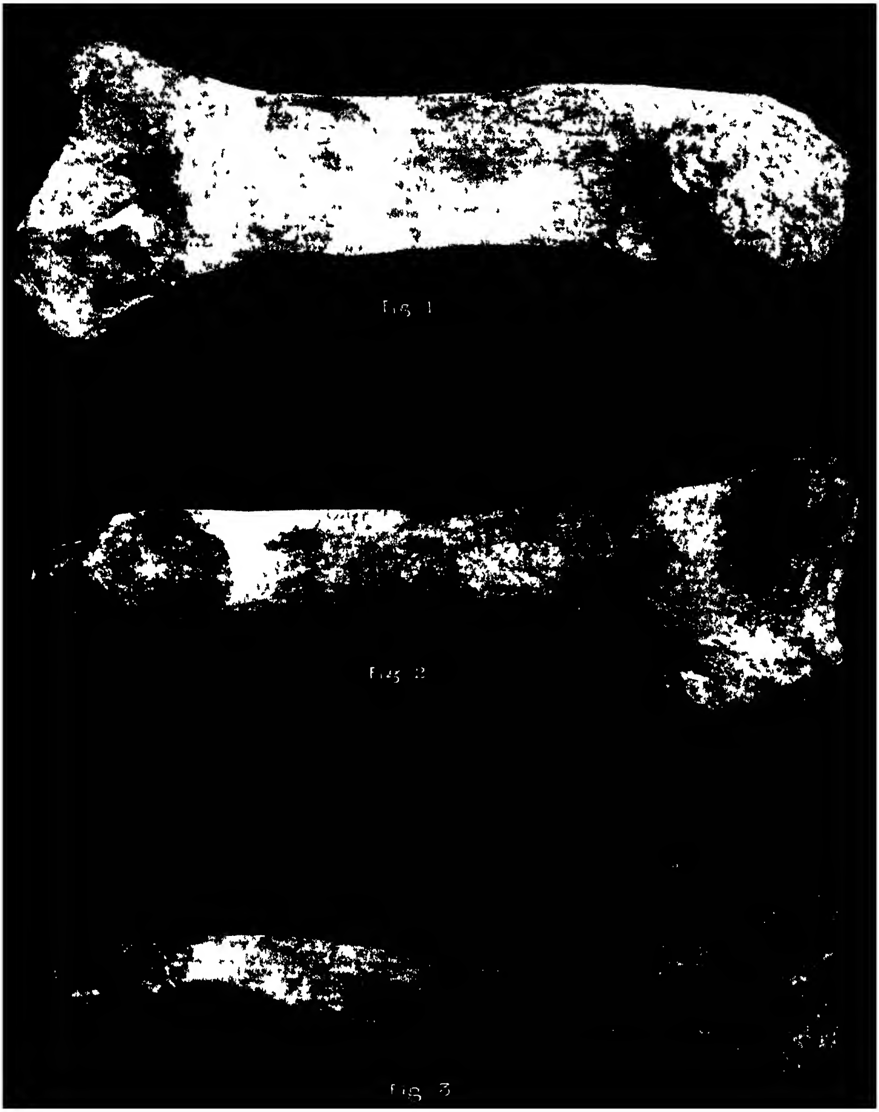
Figs. 1 & 2. RIGHT ILIUM OF LAMETASAURUS INDICUS (GEN. ET SP. NOV.)

(Scale about $\frac{1}{7}$ natural size.)

G S I Calcutta

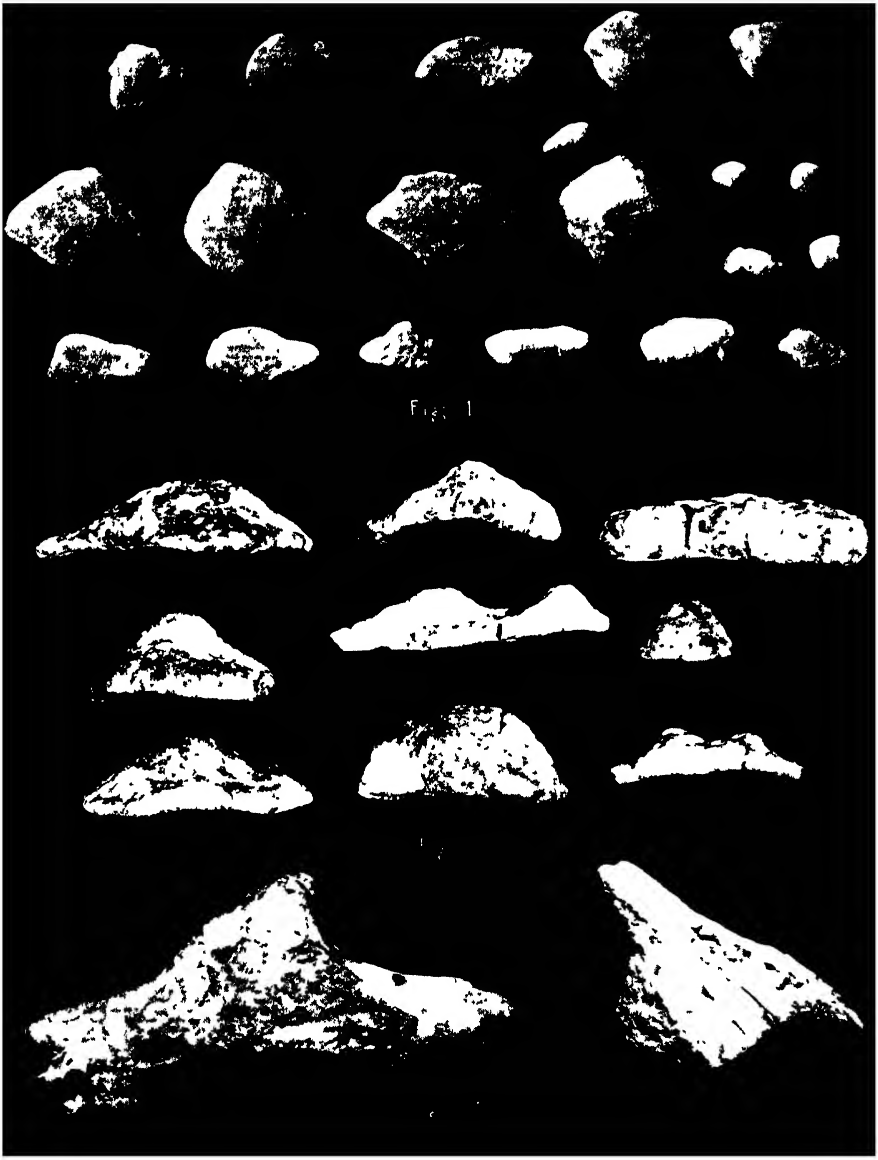
Figs 1 & 2 LEFT ILIUM OF LAMETASAURUS INDICUS (GEN ET SP NOV)

(Scale about . natural size



G S I Calcutt

Figs 1, 2 & 3 LEFT TIBIA OF LAMETASAURUS INDICUS *GEN ET SP. NOV*



G. S. I. Calcutta

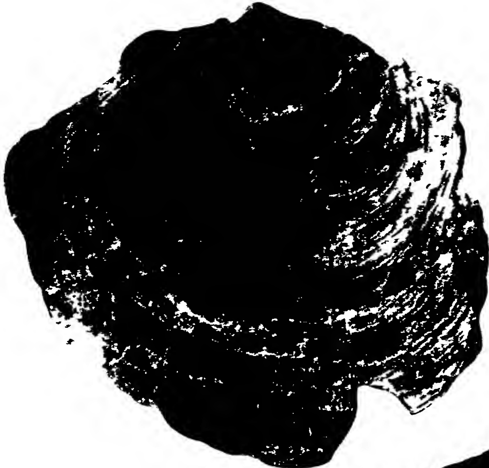
Figs 1, 2 & 3. SCUTES AND SPINES OF LAMETASAURUS INDICUS ***(GEN. ET SP. NOV.)***

(Scale, Fig. 1 about natural size, Fig. 2 about $\frac{2}{3}$ natural size, Fig. 3 about $\frac{1}{3}$ natural size.)

G. S. I. Calcutta

Figs 1 & 2 GROUP OF LARGE SCUTES OF LAMETASAURUS INDICUS (*GEN ET SP NOV*)

(*Scale about [illegible] natural size*)



1 a

1 c

1 b × 2/1

G S I Calcutta.

Z S I Photos

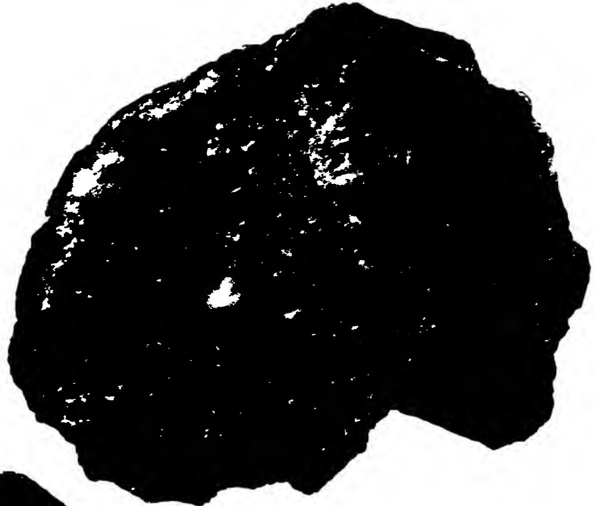
PLACUNA BIRMANICA

Z. S. I. Photos.

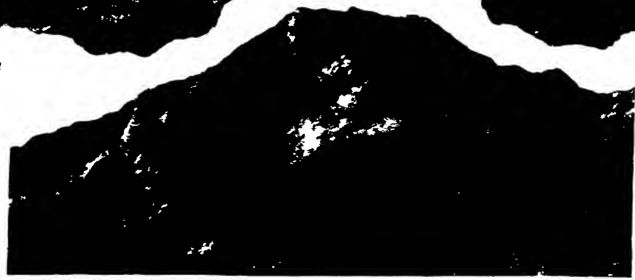
G. S. I. Calcutta.

Figs. 1d. 1e. PLACUNA BIRMANICA. Fig. 2. P. PROMENSIS.

3 *a*



3 *c*

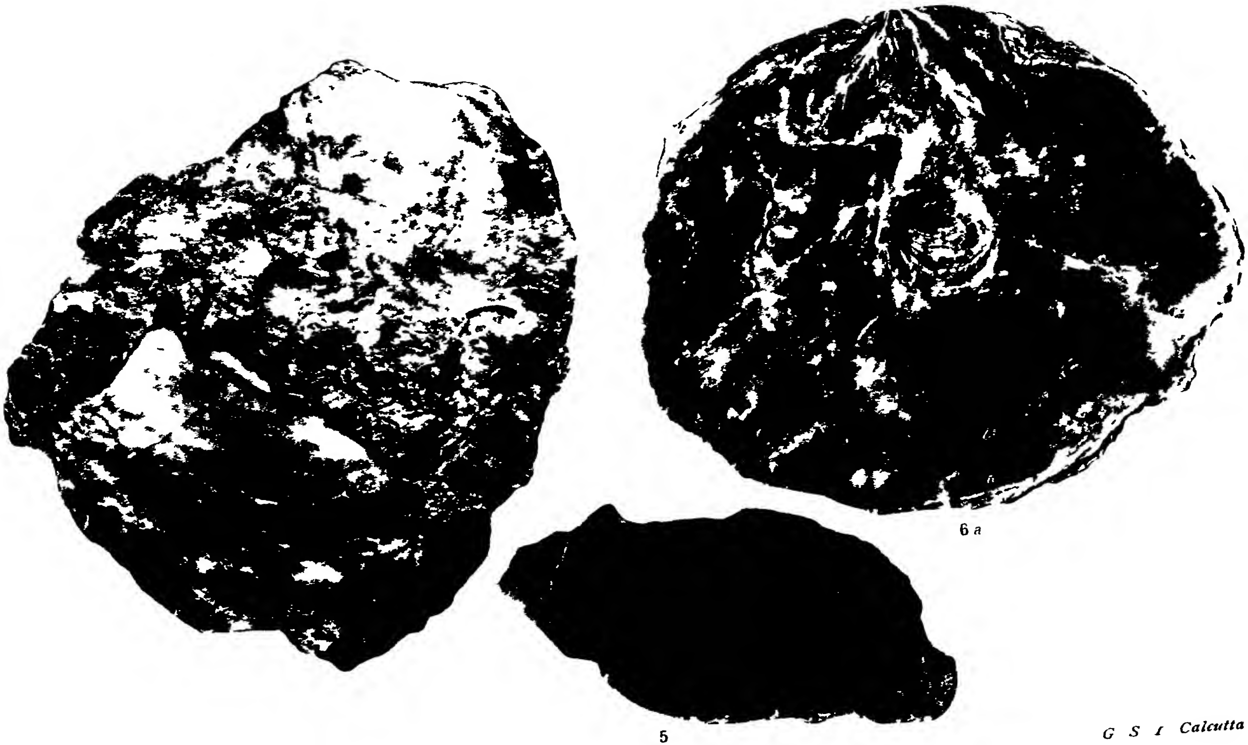


3 *b* × 3

Z. S. I Photos

PLACUNA SINDIENSIS

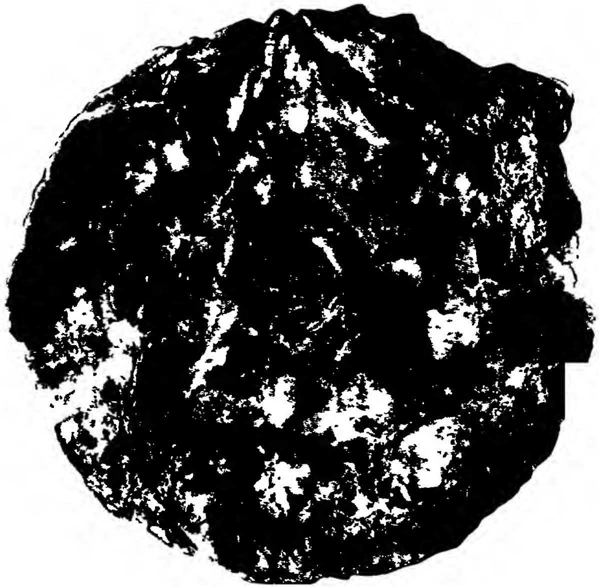
G. S I. Calcutta.



Figs 4, 5 PLACUNA SINDIENSIS. Fig 6a PLACUNA IRANICA

G S I Photos G S I Calcutta

6 *b*

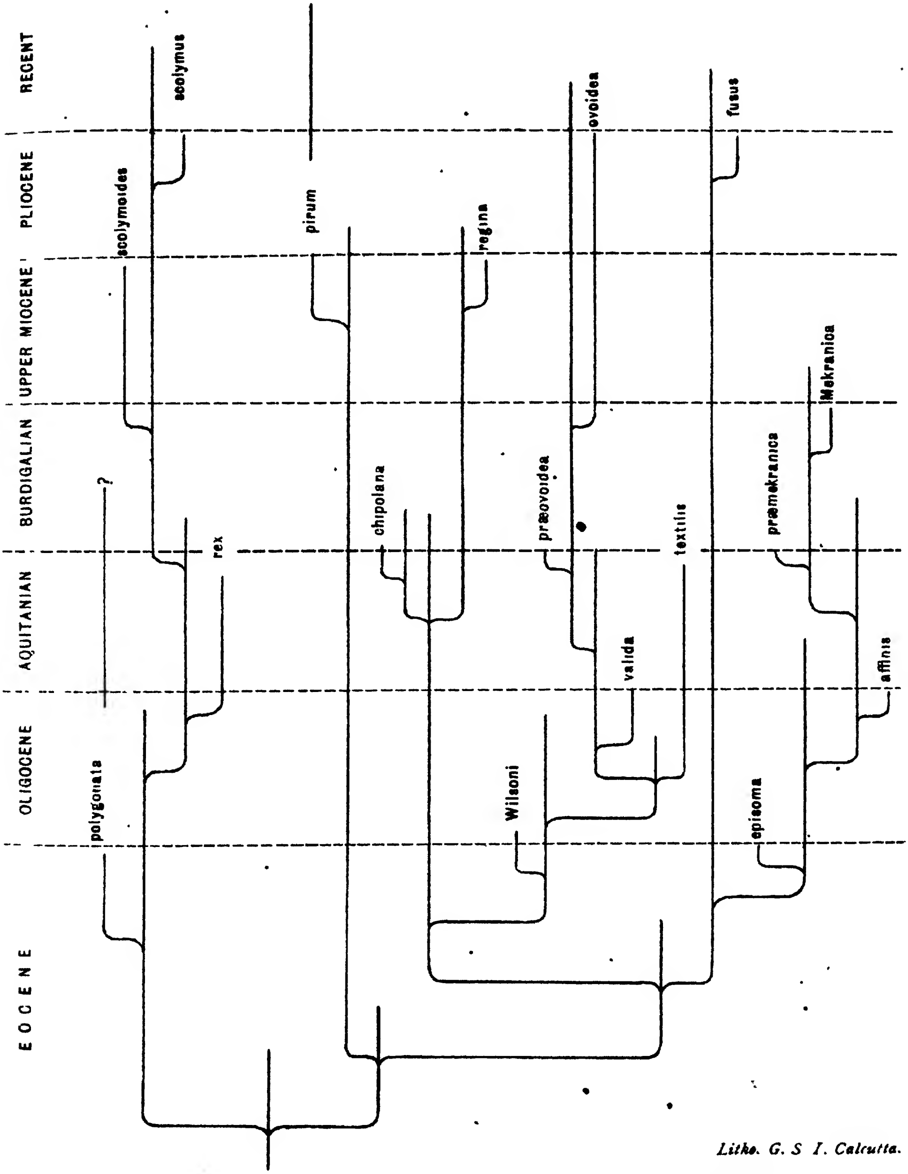


6 *c*

Z. S I Photos

G S I Calcutta

PLACUNA IRANICA



Litho. G. S I. Calcutta.

DIAGRAM ILLUSTRATING THE EVOLUTION OF CERTAIN TURBINELLIDÆ

K. F. Watkinson *G. S. I. Calcutta.*

THE SULTANPUR AEROLITE.—Fig. 1-2. Portion A. Fig. 5. Portion D.

(About natural size.)

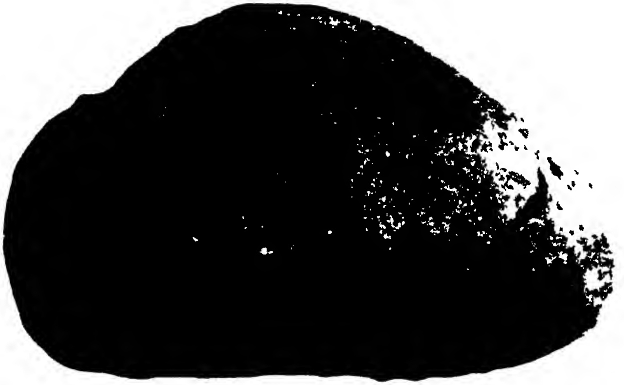
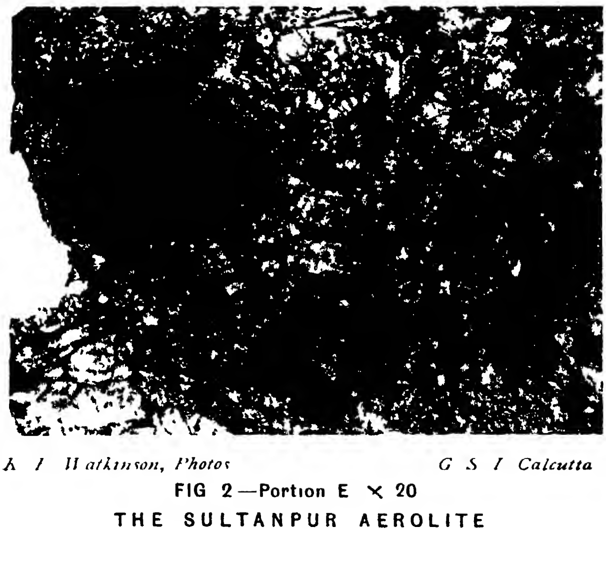


FIG. 1 Portion E *(Natural size.)*



K. F. Watkinson, Photos. *G. S. I. Calcutta.*

FIG. 2.—Portion E × 20.

THE SULTANPUR AEROLITE

Fig 1

Fig 2

Fig 3

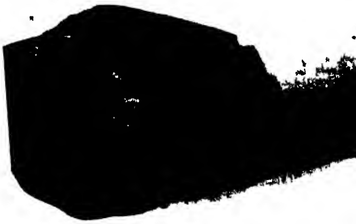


Fig 4

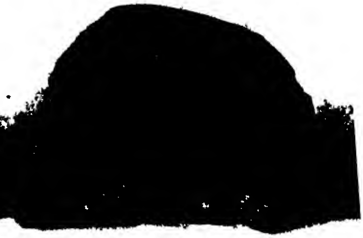


Fig 5

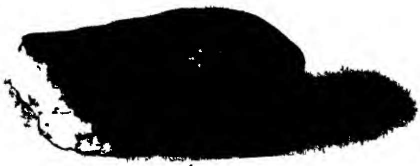


Fig 6

G S I Calcutta

H Walker & K L Wilkinson, Photos

THE RAMPURHAT AEROLITE Figs 1 3

THE RANCHAPAR AEROLITE Figs 4 5 Portion A Fig 6 Portion D

(About natural size)

Fig. 4 × 20

H Walker, Photos *G S I Calcutta*

THE RANCHAPAR AEROLITE

Figs 1 & 2. Portion B Fig 3 Fragment C Fig 4 Photo-micrograph × 20

(About natural size)

H. Walker, Photos

G S I Calcutta

THE CRANGANORE AEROLITE—Portion A

(About natural size)

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Fig. 1

Fig. 2

Fig 3

H Walker & K F Watkinson, Photo

G. S. I. Calcutta

THE CRANGANORE AEROLITE

Fig 1 Fragments B C D Figs 2, 3, 4 Portion F

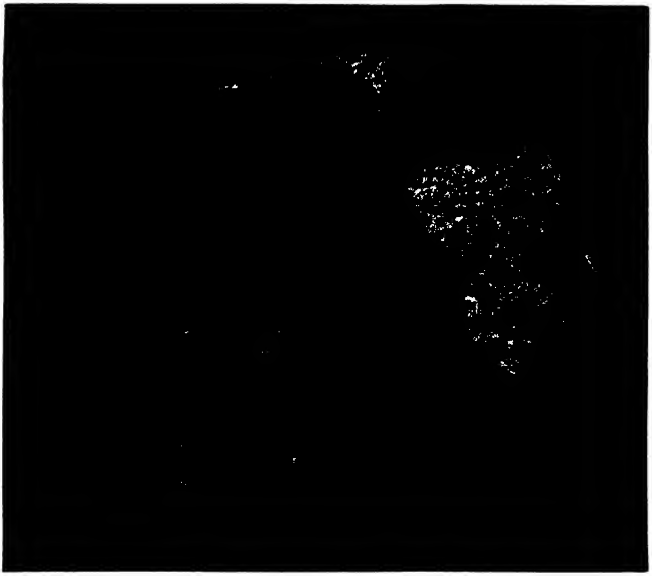
(About natural size)

H Walker, Photos

G S I. Calcutta

THE CRANGANORE AEROLITE—Portion G.

(About natural size.)



K. A. K. Hallowes, Col. Photo Micro

PYROXENITE OF DONGER DAO, HULDEE.

To face Plate 32.

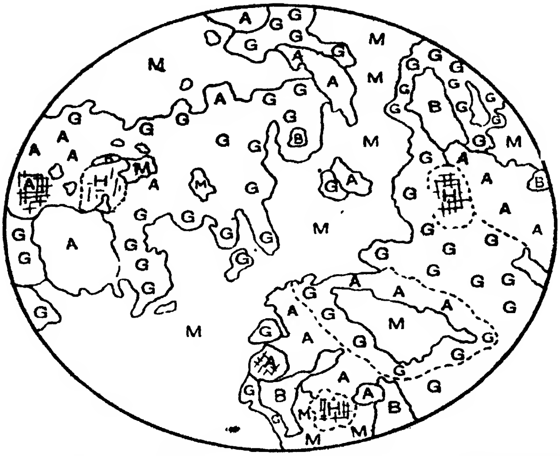


FIG. 1 GARNETIFEROUS - AUGITE - NORITE OF BONDRANEE.

Slide No 13393– Ordinary Light × 17

H – hypersthene, A augite; G garnet, B iron ore; M – quartz-felspar mosaic

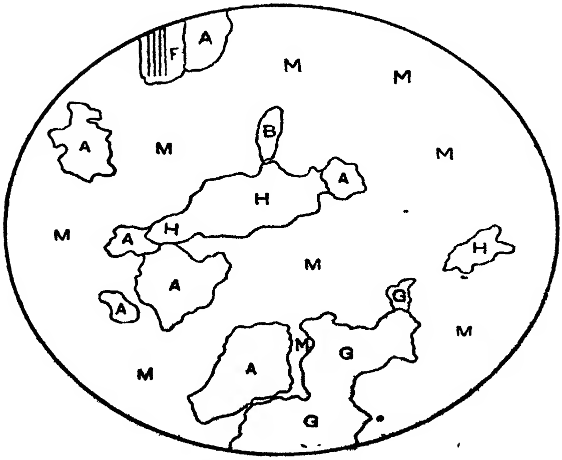


FIG. 2. AUGITE - NORITE OF SAONRA.

Slide No. 13386—Polarized Light— × 32.

H = hypersthene; A = augite; F = plagioclase felspar; G = garnet;
B = iron ore; M = quartz - felspar mosaic.

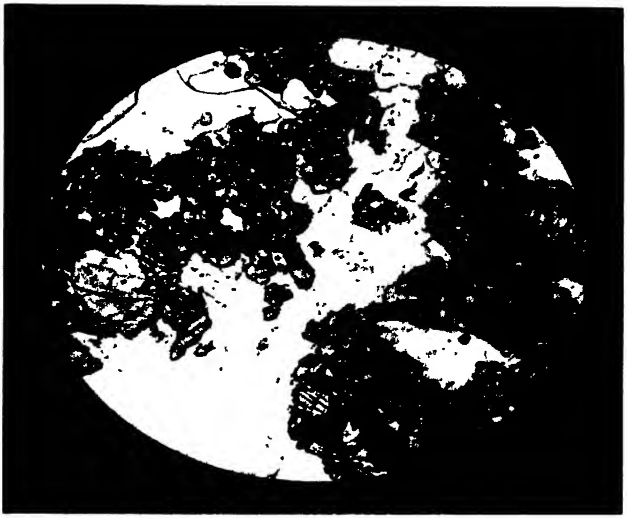
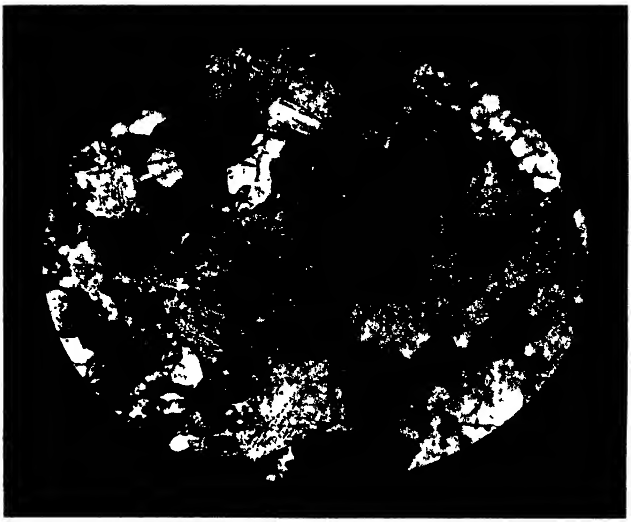


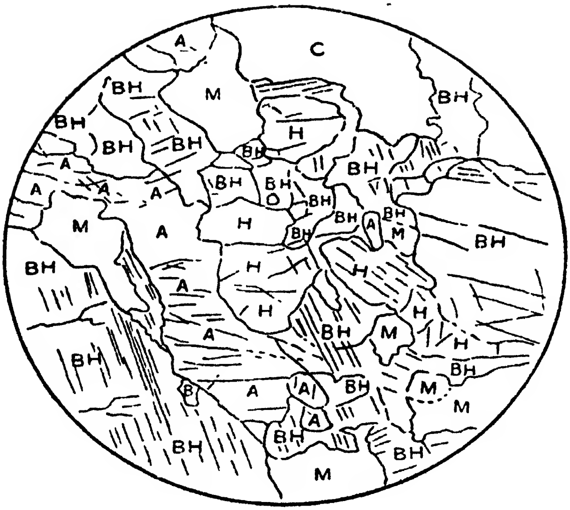
FIG. 1. GARNETIFEROUS-AUGITE-NORITE OF BONDRANEE



K A K Hallmoes, Photo. Micro G S I Calcutta

FIG 2. AUGITE-NORITE OF SAONRA.

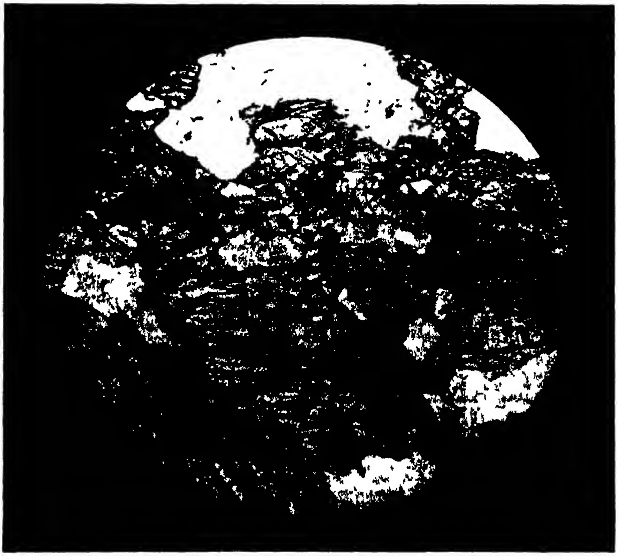
To face Plate 33.



HORNBLENDE - AUGITE - NORITE OF TAMNE.

Slide No. 13387—Ordinary Light × 32.

H = hypersthene; BH = brown hornblende; A = augite; B = iron ore; C = calcite; M = quartz-felspar mosaic.



K. A. K. Hallowes, Photo. Micro *G. S. I. Calcutta.*

HORNBLENDE-AUGITE-NORITE OF TAMNE

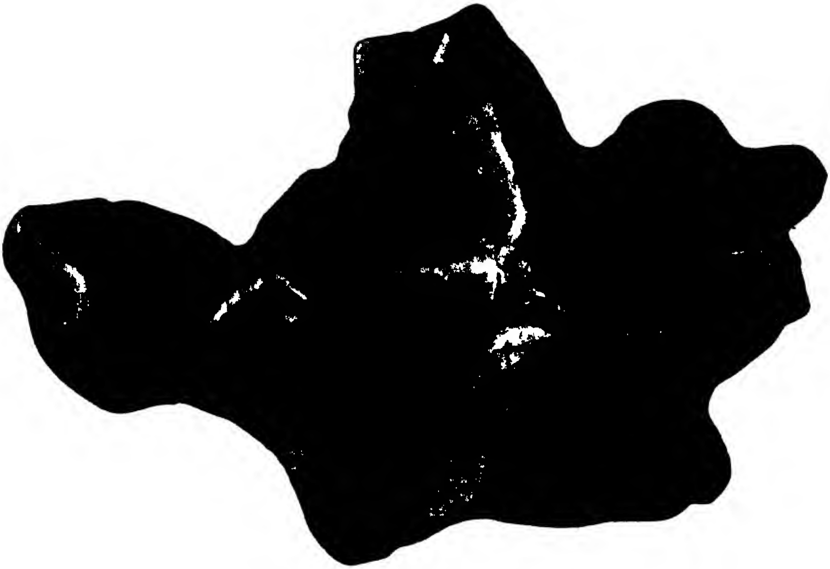


Fig 1

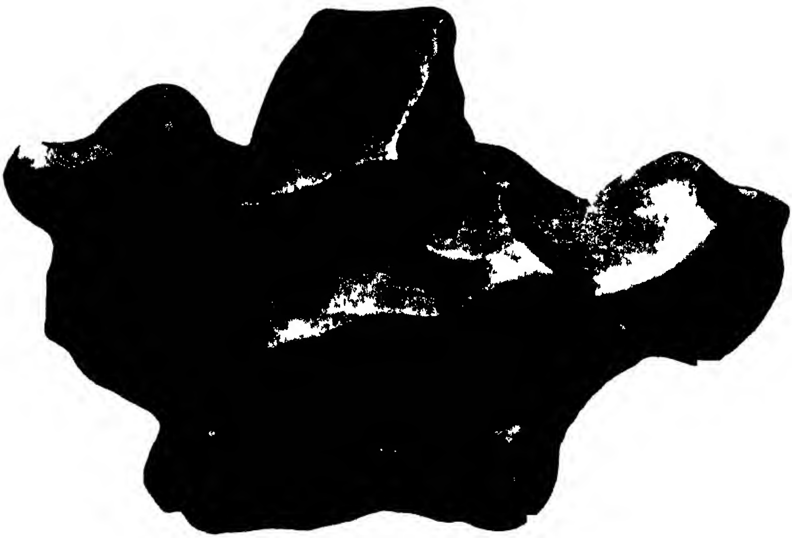


Fig 2

A. F. Watkinson, Photos

G. S. I Calcutta

IRON METEORITES

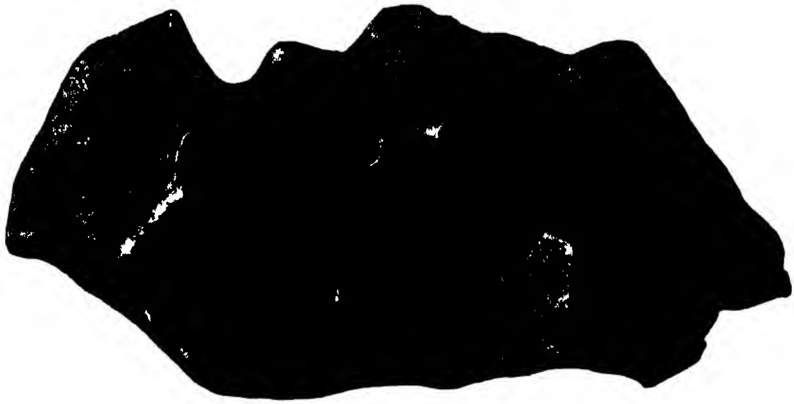


Fig 1

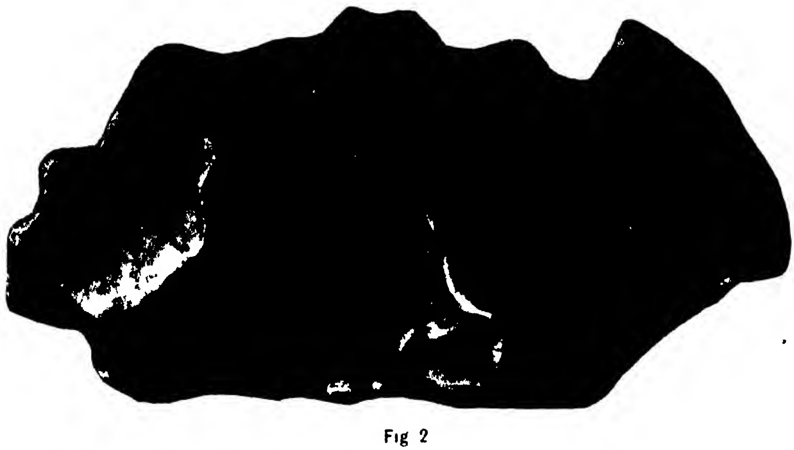


Fig 2

K. F. Watkinson, Photos

G. S. I. Calcutta

IRON METEORITES.

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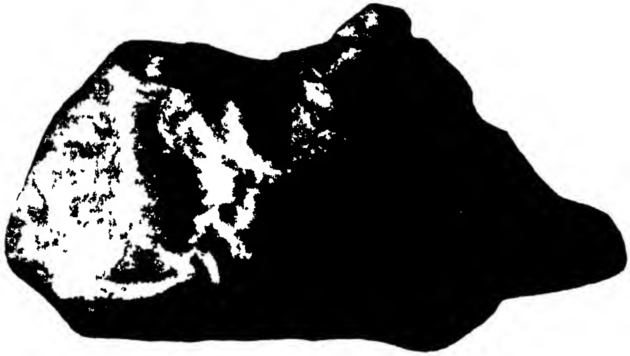

Fig. 1

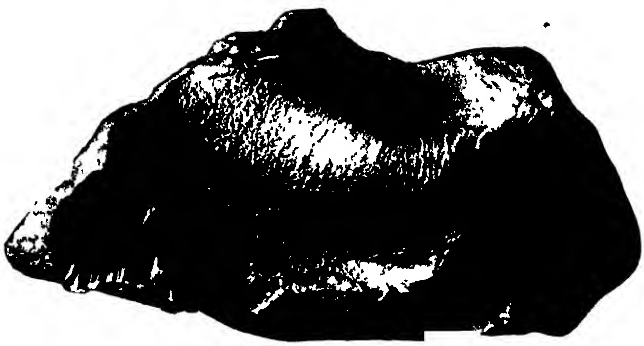

Fig. 2

K. F. Watkinson, Photos. G. S. I. Calcutta

IRON METEORITES.